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CIVIL ENGINEERS



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715 Tremont Temple, Boston

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

"The Application of the Perforating Process in the Preservative Treatment of Wood with Especial Reference to Douglas Fir." Edmund M. Blake.

"Wood Preservation." Lowry Smith.

"Douglas Fir as a Structural Timber." C. J. Hogue.

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MINUTES OF MEETINGS.

BOSTON, March 17, 1920 — The seventy-second annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, Ashburton Place, Boston, on Wednesday March 17, 1920.

The thirty-eighth annual dinner, which preceded the business meeting, was served in the auditorium of the Club-house at two o'clock P.M., the President of the Society, Mr. Leonard Metcalf, presiding.

There were 132 members and guests who partook of the dinner, and they were joined, before the after-dinner speaking began, by a number of other members who were not able to be present at the dinner.

The special guests of the Society and speakers were Mr. Frederick P. Fish, president of the National Industrial Conference; Mr. Richard H. Rice, general manager of the Lynn Works of the General Electric Company; and Mr. Franklin T. Miller, secretary and treasurer of the F. W. Dodge Company, Builders' Reports of Boston, who took for their subject different phases of the Labor Problem.

At 5.30 o'clock the business meeting was called to order by President Metcalf, in Rooms A and B of the Clubhouse. There were about one hundred members present.

The records of the last regular meeting and of its adjournment were read and approved. The Secretary reported for the Board of Government that it had elected to membership in the grade of Member, Messrs. Ernest D. Mortenson, Joseph Ernest Roy, Howard Moore Turner.

The Secretary announced the deaths of the following members of the Society: Joseph L. Carr, died February 24, 1920; John C. Olmsted, died February 24, 1920; and Orlando W. Norcross, an Associate, died February 27, 1920.

By vote the President was requested to appoint committees to prepare memoirs.

The annual reports were then taken up. The Secretary read the report of the Board of Government, and by vote it was accepted and placed on file.

The Treasurer read his annual report, which was accepted by vote and placed on file.

The Secretary then read his annual report, which was also accepted by vote and placed on file.

Mr. Berry, chairman of the Committee on Social Activities, presented and read the report of that committee, and by vote it was accepted and its recommendation adopted.

The Librarian submitted a report for the Committee on the Library, which was accepted and placed on file.

Mr. Sherman read a brief report of the Committee on Run-Off Available for Water-Power Purposes, and by vote it was accepted and referred to the incoming Board of Government with full powers.

By vote the reappointment of the several special com-

mittees of the Society was referred to the incoming Board of Government with full powers.

The question of the appointment of a Welfare Committee was, by vote, referred to the incoming Board of Government with full powers.

Mr. Frank A. Barbour, for the committee appointed to recommend the award of the Desmond FitzGerald medal for the best paper read before the Society during the year, in appropriate words presented medals to Edgar Sutton Dorr and Robert Spurr Weston, the joint authors of the paper entitled, "Disposal of Sewage by Treatment with Acid."

Both Mr. Weston and Mr. Dorr, in accepting the medals, expressed their sincere appreciations and thanks for the honor conferred upon them in being the recipients of this beautiful medal.

Mr. FitzGerald, through whose generosity the medal was instituted, being present, was called upon and responded in his usual happy manner.

The retiring President, Mr. Leonard Metcalf, then delivered the annual address of the president, which will be printed in the May number of the JOURNAL.

The tellers of election, Messrs. George A. Sampson and Clarence E. Carter, submitted the result of the letter ballot for officers of the Society, and in accordance with their report the President announced that the following officers had been elected:

President — Frank A. Barbour.

Vice-President (for two years) — Frank M. Gunby.

Secretary — S. Everett Tinkham.

Treasurer — Frank O. Whitney.

Directors (for two years) — John E. Carty and Henry B. Wood.

Members of the Nominating Committee (for two years) — Walter W. Clifford, Harry F. Sawtelle and Dana M. Wood.

The President then introduced the President-elect, Mr. Frank A. Barbour, who expressed his sincere thanks for the honor conferred on him in this election, and asked the members for their earnest coöperation in the work of the Society for the coming year.

Colonel Gunby in accepting the office of Vice-President promised his hearty support and best efforts in promoting the welfare of the Society.

At 6.45 o'clock the meeting adjourned to the auditorium of the Club, where the annual smoker took place. On their entrance the members found light refreshments awaiting, pipes and tobacco in abundance and a supply of paper caps of the hue which is so much in evidence on the 17th of March. Instrumental music was furnished throughout the evening by New England's Jazz-Kings, of six pieces, and the Apollo Quartet rendered a number of vocal selections which were greatly enjoyed. Another feature of the evening very much enjoyed was the dialect stories by Jack Liden, familiarly known as "Duffy," a clean-cut and wholesome American sailor, who drew many bright, new and funny stories from his well-stocked ditty bag. Four motion pictures were shown during the evening, one entitled "Through Life's Windows," another "Why We Boil Water," and two comedy pictures.

The arrangements for the smoker were in the hands of the Committee on Social Activities, and much credit is due them for the very efficient manner in which the entertainment was carried out.

The attendance at the smoker was 235, and the total attendance of members and guests at the several functions of the day was over 275.

S. E. TINKHAM, *Secretary*.

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, March 3, 1920. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society rooms, Tremont Temple.

Commencing at 6.30 o'clock, a social hour was enjoyed. Refreshments were served by the Committee on Social Activities.

At 7.30 o'clock the business meeting was called to order by the chairman, Edgar S. Dorr.

The report of the February meeting was read and approved.

The report of the Executive Committee was read by the clerk, and was accepted and ordered placed on file.

Mr. A. L. Fales, for the Nominating Committee, presented the following nominations for officers for the ensuing year:

Chairman — Edward Wright.

Vice-Chairman — Philip W. Taylor.

Clerk — John P. Wentworth.

Executive Committee —

Charles R. Berry.

Gordon M. Fair.

Robert Spurr Weston.

The clerk was instructed to cast one ballot for the named nominees.

On motion of Mr. Chase, a rising vote of thanks was extended to Mr. Dorr for his successful work as chairman during the past year.

Following the business meeting Col. Frank M. Gunby spoke on "Living Conditions in the Orient." Colonel Gunby described the customs of the natives of the Orient and their living and sanitary conditions. The talk was illustrated by lantern slides.

Chairman Dorr introduced the new chairman, Edward Wright, who made a few remarks on the work of the Section for the coming year.

Adjourned at 7.45 P.M. Members present, 41.

JOHN P. WENTWORTH, *Clerk*.

ANNUAL REPORTS.

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1919-1920.

BOSTON, March 17, 1920.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 17, 1920.

Membership.

The total membership of the Society a year ago was 888, of whom 791 were members, 57 juniors, 8 honorary, 26 associates, and 6 were members of the Sanitary Section only.

During the year 10 members have resigned, 20 have forfeited member-

ship for non-payment of dues, 1 junior has lost membership because of age limit, and 12 have died, making total deductions of 43.

Thirty-six members in all grades have been added during the year, of whom 8 were former members reinstated, and 6 juniors have been transferred to the grade of member.

The present membership of the Society consists of 7 honorary members, 786 members, 55 juniors, 29 associates, and 4 who are members of the Sanitary Section only, making a total membership of 881.

Deaths.

The loss by death during the year has been 12, as follows:

John A. Gould, May 18, 1919.
 Charles E. Putnam, August 20, 1919.
 Edward S. Shaw, October 3, 1919.
 Edmund Grover, October 20, 1919.
 Irving S. Wood, October 20, 1919.
 Henry Manley, October 28, 1919.
 Frederic P. Stearns, December 1, 1919.
 Frank L. Fuller, January 20, 1920.
 R. Winthrop Pratt, February 2, 1920.
 Joseph L. Carr, February 12, 1920.
 John C. Olmsted, February 24, 1920.
 Orlando W. Norcross, February 27, 1920. (Associate.)

Remission of Dues.

Under authority of By-Law 8, the Board of Government has remitted the dues of 6 members.

Under vote of the Society passed at the annual meeting last year, the dues of 65 members have been abated in full or in part on account of war service, and under the same vote the sum of \$281.69 has been transferred from the income of the Permanent Fund to the Current Fund, to make good the loss in the yearly income of the Society.

Regular Meetings.

Ten regular and two special meetings and one adjourned meeting have been held during the year.

The average attendance at these meetings was 108+, the largest being 275 and the smallest 25.

The following papers and addresses have been given:

March 19, 1919. — Address of the retiring President, Charles M. Spofford, "Reconstruction and the Engineer." Address by Gen. R. C. Marshall, Jr., on "Cost-Plus Form of Contract." Col. Frank M. Gunby, "Work of the Construction Division of the U. S. Army" (illustrated).

April 16, 1919. — Lieut.-Col. Benjamin W. Guppy, "A Year with the British Expeditionary Force." Major Lewis E. Moore, "Military Bridges." (Both illustrated.)

May 12, 1919. — Joint Meeting with the Boston Section of the American Society of Mechanical Engineers. Frederic H. Fay, Past-President, "Estab-

lishment of a National Department of Public Works," with supplementary discussions by a number of others.

June 25, 1919. — Address by Hon. William W. Blodgett, "Personal Experiences in Y. M. C. A. Work in France."

September 17, 1919. James W. Rollins, "New Boston Dry Dock." Frank W. Hodgdon, "Equipment of Dry Dock."

October 15, 1919. — Charles H. Eglee, "The Industrial Unrest."

October 29, 1919. (Special.) — Discussion on "Compensation of Engineers."

November 12, 1919. — Discussion on "Cost-Plus and Other Forms of Contract."

November 19, 1919. — George W. Fuller, "Future Opportunities and Obligations of Engineers."

December 17, 1919. — Allen Hazen, "Hydraulic Fill Dams" (illustrated).

January 28, 1920. — A. N. Johnson, "Construction of Concrete Roads" (illustrated).

February 18, 1920. — Edmund M. Blake, "Douglas Fir Industry." Chester J. Hogue, "Douglas Fir for Structural Uses." Lowry Smith, "Wood Preservation" (illustrated).

February 25, 1920. (Adjourned meeting.) — Discussion of Report of Committee on Compensation of Engineers.

Sanitary Section Meetings.

The Sanitary Section has held six meetings and one excursion during the year. The following papers have been presented at the meetings of the Section:

March 5, 1919. (Annual meeting.) — Lieut.-Col. George A. Johnson, "The Operation and Maintenance of Utilities at Army Camps and Cantonnments."

May 7, 1919. — Prof. C. T. Brues, "The Sanitary Control of Mosquitoes, Flies and Other Insects."

June 4, 1919. — H. W. Rowley, "The Final Disposal of Boston City Wastes."

November 5, 1919. — Discussion, subject: "Outfall Sewers."

December 3, 1919. — Gordon M. Fair, "Recent Developments in the Use of Ultra Violet Light."

February 11, 1920. — Eugene F. Leger, "Small Pumping Stations."

The average attendance at the Sanitary Section meetings was 28.

Excursion.

On June 5, 1919, an excursion was made to the Garbage Reduction Plant at Spectacle Island.

Special Meetings for Designing Engineers.

With a view to increasing the usefulness of the Society to its younger members, a series of meetings was planned for the presentation and discussion of interesting current problems in engineering design, upon which some of these men had recently been engaged. One or two, only, of the older, more experienced members of the Society were asked to be present at the meetings, to broaden and draw out discussion and answer questions, as it was desired

to create an atmosphere which would lead the younger men into active participation in the discussion, rather than to remain silent listeners. Meetings have been held at six o'clock in the evening, the hour suggested by the men, every two weeks, alternating with the regular meetings of the Society, and have been led by the following men:

February 11, 1920. — Frank A. Marston, "Difficult Foundation Problems Involved in the Design of the New Sewage Treatment Plant at Milwaukee, Wis., and Their Proposed Solution." Discussion by Col. Charles R. Gow.

February 25, 1920. — C. A. Farwell, "Concrete Foundations at the Boston Army Supply Base." Discussion by Col. Charles R. Gow, constructing quartermaster, U. S. A., upon this work.

March 10, 1920. — Harry E. Sawtell, "The Foundations of the New Massachusetts Institute of Technology Buildings." Discussion by Col. Frank M. Gunby.

The attendance at these meetings was respectively 38, 43 and 36, and the interest has been keen. Plans have already been made for a continuation of these talks upon different subjects, and the Board of Government is considering the most effective way of carrying on this work, — by committee, as a section of the Society or otherwise.

Welfare Work.

The Society has taken an active interest during the year in welfare work.

A Committee on Compensation of Engineers was appointed to study the subject. Two special meetings of the Society were held for discussion of this subject, and the committee now has in preparation its final report. Acting upon the recommendation of the Committee on Compensation of Engineers, it is anticipated that the incoming Board of Government will appoint a Committee on Welfare.

The President and certain members of the Society appeared before the legislative committee on Senate Bill 196, bearing upon the increase in compensation of engineers in the public service.

The Society instituted a movement intended to draw out expressions of opinion from the different professional societies in Boston and vicinity, as to the desirability of some form of association or coöperation without loss of identity, that might give to the affiliated societies the advantage of increased influence in public matters, — growing out of unity of purpose and action, — and of decrease in cost of administration and maintenance, through combination and common use of certain facilities. A luncheon was held at the Boston City Club, at which representatives of seventeen organizations discussed this question, the President of your Society being elected chairman of the meeting and entrusted with the appointment of a committee of five to investigate the subject and to report its findings to the conference, with draft for form of organization which might furnish the basis of future action, should it find coöperation advantageous. The following committee was appointed; Prof. George F. Swain of Harvard University, chairman; Peter

Junkersfeld, engineering manager of Stone & Webster; I. E. Moulthrop, assistant superintendent, Construction Department of Edison Electric Company; Stanley B. Parker, architect; and Beardsley Lawrence, civil engineer and secretary of the local section of the American Association of Engineers.

Your Society has also taken an active interest in the movement to convert the U. S. Department of the Interior into a National Department of Public Works, sending as its representative to the conference held in Chicago, on April 23-26, 1919, Past-President Frederic H. Fay, who was accompanied by your President, representing the American Water Works Association. Subsequent meetings of the National Department of Public Works Association were attended by these men, and two meetings of this Society were held during the year jointly, with the members of the Boston Section of the American Society of Mechanical Engineers, for the discussion of this subject, the first meeting being led by Mr. Frederic H. Fay and the second by Prof. George F. Swain, who was appointed chairman of the New England District and of the Massachusetts Committee of the National Department of Public Works Association at the suggestion of your representatives.

A representative of the Board met, in conference, representatives of the architects and of some of the labor unions of the city, upon the project for the widening of Tremont and Boylston streets on the Common. A representative of the Board also appeared before a legislative committee on the petition of the Young Men's Christian Association for authority to award certain degrees to its students.

The Committee on Matters of Interest to Engineers coming before the Massachusetts legislature has been continued during the year.

Permanent Fund.

At the February meeting it was voted to appropriate the entire income of the Permanent Fund for the current year and place the same at the disposal of the Board of Government for use in payment of the expenses of the Society so far as deemed advisable in its judgment. Under this vote the sum of \$1 055.26 has been used in the payment of current expenses of the past year.

Notwithstanding the amount appropriated from the current income of the Permanent Fund of the Society for the payment of dues of war members and current expenses, there has been added to this fund during the year the sum of \$385. The present value of this fund is \$43 852.51, and, with the Edward K. Turner Fund amounting to \$1 058.72, the permanent funds of the Society amount to the sum of \$44 911.23.

Cost of Journal.

The report of the Editor of the JOURNAL for the calendar year 1919 shows that ten issues, of 1 250 copies each, have been printed, comprising a total of 682 pages. The net cost of the JOURNAL was \$2 154.40, or \$3.10 per page. In 1918 the net cost was \$2 367.75, or \$3.22 per page. The some-

what more favorable showing for 1919 was brought about largely by keeping the number of cuts at a minimum and by an increase in the amount of advertising carried. At the close of the year the amount of paid advertising space was somewhat greater than at any previous time in the history of the JOURNAL.

Award of Desmond FitzGerald Medal.

In accordance with the recommendation of the committee appointed to consider the award of the Desmond FitzGerald medal for the best paper by a member of the Society published during the year ending September, 1919, the Board has awarded the medal to Edgar Sutton Dorr and Robert Spurr Weston, for their paper entitled, "The Disposal of Sewage by Treatment with Acid."

Work of Committees.

The Board expresses its appreciation of the conscientious and effective work done by the standing and special committees. The work of the Committee on Social Activities deserves special commendation.

For the Board of Government,

LEONARD METCALF, *President.*

REPORT OF THE TREASURER.

BOSTON, March 1, 1920.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year ending March 1, 1920:

Detailed data are contained in the appended tabular statements; Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; Table 3, investment of the Permanent Fund.

The current expenses for the year amount to \$9 811.75, being \$1 170.07 increase over the preceding year.

In addition to the cash on hand at the beginning of the year, which amounted to \$109.04, there has been used the sum of \$1 055.26 from the income of the Permanent Fund.

The net expense of the JOURNAL has been \$150.46 more than last year. The income from advertisements increased \$263.50. Otherwise the JOURNAL expenses would show an increase of \$413.96.

There has been an increase in the Permanent Fund of \$385 after transferring from the income — which amounted to \$2 264.40 — the sum of \$281.69 for dues of members in the war service, and the balance, amounting to \$1 982.71, to a fund to be used for current expenses.

There has been \$500 invested in a 4¾ per cent. Victory Bond.

Respectfully submitted,

F. O. WHITNEY, *Treasurer.*

PROCEEDINGS.

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TABLE I. — RECEIPTS AND EXPENDITURES.

CURRENT FUND.

Receipts.

Balance from March 1, 1919.....	\$109.04
Members' dues.....	6 779.98
Members' dues paid from income of Permanent Fund.....	281.69
Advertisements.....	1 389.00
Sales of JOURNALS.....	180.16
Library fines.....	7.97
Old paper sold.....	5.53
Interest on bank balances.....	3.12
Deficit paid from income of Permanent Fund.....	1 055.26
	\$9 811.75

Expenditures.

JOURNAL.....	\$3 945.28
Printing, stationery, postage, etc.....	955.06
Rent (net).....	1 775.00
Light.....	63.39
Salaries (except Editor).....	2 382.00
Reporting.....	105.50
Stereopticon.....	18.00
Binding.....	81.20
Periodicals.....	86.25
Incidentals.....	147.19
Insurance.....	36.83
Annual meeting and dinner.....	111.70
Sanitary Section, incidentals.....	\$25.85
Reporting.....	42.00
Printing.....	36.50
	\$9 811.75

PERMANENT FUND.

Receipts.

Cash on hand, March 1, 1919.....	\$308.61
Entrance fees.....	285.00
Contributions.....	100.00
Interest received (net).....	1 842.30
Securities to be paid for.....	1 128.49
	\$3 664.40

Expenditures.

Coöperative bank dues.....	\$900.00
Victory Bond purchased.....	500.00
Transferred to Current Fund account.....	2 264.40
	\$3 664.40

BOSTON SOCIETY OF CIVIL ENGINEERS.

E. K. TURNER LIBRARY FUND.

Cash on hand March 1, 1919.	\$69.47
Interest on bond.	50.00
	\$119.47
Books purchased.	\$54.50
Cash on hand March 1, 1920.	64.97
	\$119.47

INCOME FUND FOR CURRENT EXPENSES.

Interest from invested funds.	\$1 842.30
Coöperative banks, accrued interest.	422.10
	\$2 264.40
Paid dues of members in war service.	\$281.69
Paid deficit in current expenses.	1 055.26
Balance.	927.45
	\$2 264.40

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.	March 1, 1917.	March 1, 1918.	March 1, 1919.	March 1, 1920.
Cash.	\$1 443.47	\$478.95	\$487.12	\$333.49
Bonds and notes.	33 318.75	34 835.00	35 023.00	35 523.00
Stock.	1 950.00	1 950.00	1 950.00	1 950.00
Coöperative banks.	4 747.15	5 930.85	7 179.65	8 501.75
Library.	7 500.00	7 500.00	7 500.00	7 500.00
Furniture.	2 405.11	2 405.11	2 405.11	2 405.11
	\$51 364.48	\$53 099.91	\$54 544.88	\$56 213.35
Liabilities.				
Permanent Fund.	\$39 888.17	\$41 687.92	\$43 467.51	\$43 852.51
E. K. Turner Fund.	997.87	1 023.12	1 063.22	1 058.72
Unexpended appropriations.		105.92		927.45
Current funds.	573.33	377.84	109.04	
Unpaid bills.				469.56
Surplus.	9 905.11	9 905.11	9 905.11	9 905.11
	\$51 364.48	\$53 099.91	\$54 544.88	\$56 213.35

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 1, 1920.

Bonds.	Par Value.	Actual Cost.	Value as carried on Books.
American Tel. & Tel. Co. Col. Tr. 4%, 1929.	\$3 000.00	\$2 328.75	\$2 737.50
Union Elec. Light & Power Co. 5%, 1932...	2 000.00	2 050.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1939	2 000.00	1 995.00	1 995.00
Dayton Gas Co. 5%, 1930.....	2 000.00	2 000.00	2 000.00
Milford & Uxbridge St. Ry. 7%, 1923	2 000.00	2 942.50	2 942.50
Railway & Light Securities Co. 5%, 1939...	3 000.00	3 000.00	3 000.00
Superior Light & Power Co. 4%, 1931.....	4 000.00	3 347.50	3 347.50
Wheeling Electric Co. 5%, 1941.....	4 000.00	3 845.00	3 845.00
Economy Light & Power Co. 5%, 1956.....	1 000.00	990.00	990.00
Tampa Electric Co. 5%, 1933.....	2 000.00	2 000.00	2 000.00
Galveston Houston Elec. Ry. Co. 5%, 1954.	2 000.00	1 940.00	1 940.00
Northern Texas Elec. Co. 5%, 1940.....	2 000.00	1 932.50	1 932.50
Chicago & Northwestern Ry. 5%, 1987	1 000.00	1 102.50	1 102.50
Vermont Power & Mfg. Co. 5%, 1928.....	1 000.00	965.00	965.00
Am. Tel. & Tel. Co. 5%, 1946.....	1 000.00	993.75	993.75
United States Liberty Loan 3½%, 1947....	2 000.00	2 000.00	2 000.00
Am. Tel. & Tel. Co. 6%, 1925.....	200.00	188.00	188.00
United States Victory Loan 4¾%, 1923....	500.00	500.00	500.00
	\$35 700.00	\$34 120.50	\$34 529.25
Stock.			
15 shares Am. Tel & Tel. Co.....	1 500.00	1 950.00	
Total Securities.....	\$37 200.00	\$36 070.50	\$36 479.25
Coöperative Banks.			
25 shares Merchants Coöperative Bank, including interest to March.....		\$2 730.05	
25 shares Volunteer Coöperative Bank, including interest to January.....		3 022.50	
25 shares Watertown Coöperative Bank, including interest to March.....		2 749.20	8 501.75
Total value of invested funds.....			\$44 981.00
Securities to be paid for.....			1 128.49
Total value of Permanent Fund.....			\$43 852.51

BOSTON SOCIETY OF CIVIL ENGINEERS.

E. K. Turner Fund.

	Par Value.	Actual Cost.	
Am. Tel. & Tel. Co. 5%, 1946 .	\$1 000.00	\$993.75	\$993.75
Cash on hand			64.97
			1 058.72
Income for Current Expenses.			
Credit from Permanent Fund			927.45
			\$45 838.68

We have examined the above report and found it correct.

EDWIN H. ROGERS,
JOHN L. HOWARD,
*Auditing Committee of Directors of
the Boston Society of Civil Engineers.*

REPORT OF SECRETARY, 1919-20.

BOSTON, March 17, 1920.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS, *Dr.*

For cash received during the year ending March 17, 1920, as follows:

From entrance fees, new members and transfer:

23 members and associates	at \$10,	\$230.00
5 juniors	at 5,	25.00
6 juniors transferred to members	at 5,	30.00

Total from entrance fees	\$285.00
From annual dues for 1919-20, including dues from new members	\$6 623.98
From back dues	80.00
From dues for 1920-21	76.00

Total from dues	6 779.98
From rents	1 300.00
From advertisements	1 389.00
From sale of JOURNALS and reprints	180.16
From library fines	7.97
From sale of old paper	5.53
From contribution to building fund	100.00

Total \$10 047.64

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

JOHN L. HOWARD,
EDWIN H. ROGERS,
*Auditing Committee of Directors of
Boston Society of Civil Engineers.*

REPORT OF THE LIBRARIAN.

BOSTON, March 17, 1920.

To the Boston Society of Civil Engineers:

The Librarian submits for the Committee on the Library the following brief report for the year 1919-20.

Because of the absence of the Assistant Librarian for the past two months and more, due to a severe sickness, not as much has been accomplished in the cataloging this year as for a number of years past, and at present only such work is going on as is deemed necessary to keep the books and periodicals accessible for the use of members.

Since the last report, 98 volumes bound in cloth and 342 bound in paper have been added to the library, making a total of 440 accessions. There are now 9 622 bound volumes in the library, and those bound in paper number a little over 3 000.

During the year 260 books have been loaned to members, and fines to the amount of \$7.97 have been collected.

Twelve new standard engineering books have been added to Section 10, purchased from the income of the E. K. Turner Fund, and four others, "Building of a Wooden Ship," by T. W. Clarke; "Highways of Europe," by A. H. Blanchard; "The Turnpikes of New England," by F. J. Wood; "Vital Statistics," by G. C. Whipple, have been presented to the library by their respective authors. In addition, miscellaneous contributions of books and pamphlets have been received from the late Frank L. Fuller, G. W. Rollins, C. T. Main, L. H. Allen and others.

The amount of binding for the library done this year, while about the same as last year, is still less than usual. This is partly due to the greatly increased cost of such work and partly to the difficulty in securing complete files of some of the periodicals because of the trouble last fall in New York City with the magazine printers.

The Catalogue Equipment and Supply Company have continued keeping up to date the collection of trade catalogues placed in our library, and pocket indexes to these catalogues will be furnished to members on request.

Respectfully submitted,

S. EVERETT TINKHAM, *Librarian.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 3, 1920.

To the Boston Society of Civil Engineers:

The Sanitary Section has held six meetings, the subjects and speakers being as follows:

March 5, 1919. — Annual meeting. "The Operation and Maintenance of Utilities at Army Camps and Cantonments." Lieut.-Col. George A. Johnson.

May 7, 1919. — "The Sanitary Control of Mosquitoes, Flies and Other Insects." Prof. C. T. Brues.

June 4, 1919. — "The Final Disposal of Boston City Wastes." H. W. Rowley.

November 5, 1919. — Discussion. Subject: "Outfall Sewers."

December 3, 1919. — "Recent Developments in the Use of Ultra Violet Light." Gordon M. Fair.

February 11, 1920. — "Small Sewage Pumping Stations." Eugene F. Leger.

The average attendance at these meetings was 28.

On June 5, 1919, an excursion was made to the Garbage Reduction Plant at Spectacle Island.

Membership. — Five new members have been added during the year, making a present total membership of 169.

Special Committee. — There is a special committee on "Methods of Design and Construction and Results of Operation of Submerged Pipe Lines for Outfall Sewers." It is recommended that this committee be continued for another year.

There is also a special committee on "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water." Two of the members of this committee, William S. Johnson and Rufus M. Whittet have been taken away by death. It is recommended that Prof. Dwight Porter, the other member of this committee be authorized to appoint two new members to assist him in completing the work of this committee.

Respectfully submitted,

For the Executive Committee,

JOHN P. WENTWORTH, *Clerk.*

REPORT OF COMMITTEE ON SOCIAL ACTIVITIES.

BOSTON, MASS., March 17, 1920.

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits this annual report for the year 1919-20.

On June 25, 1919, the Boston Society of Civil Engineers and the New England Water Works Association held the annual Field Day at Pemberton, Mass. The baseball game which was scheduled to take place between the two societies was not played because of the failure of the New England Water Works team to put in an appearance. A scrub game was substituted and was very much enjoyed by all, especially the hard-hitting portly gentlemen who were obliged to run bases often. Dinner was served in the Pemberton Inn dining-room, after which the party adjourned to the lawn, where, after a short business meeting, they were addressed by Hon. Wm. E. Blodgett, ex-mayor of Woburn, Mass. Mr. Blodgett was a Y. M. C. A. secretary in France, and brought to us a new view of the work among the boys. All of the 127 present agreed the outing a big success.

During the fall and winter months, through the generosity of one of the members, the committee were enabled to give to the members, free of charge, a luncheon and smoker before the regular meetings. The first social hour was held on November 19, 1919, at 7.00 P.M. On December 17, 1919, we started at 6.30 P.M., and on January 28, 1920, we began at 6.00 P.M. The interest continued to grow with each meeting, which necessitated the change of hour. On February 18, 1920, we started at 6.00 P.M. This was the last of these meetings and was the best attended of any, which proved to the committee that it was on the right track.

On March 3, 1920, the committee provided refreshments at the annual meeting of the Sanitary Section.

These meetings have been well attended, and the spread of good-fellowship and sociability among the members has been very noticeable. Some members who had not attended a meeting for years began to come back, and new members have been added to the Society. We believe this to be our mission, and we have endeavored to do our bit.

The committee has been asked to take charge of the Annual Smoker at the City Club this year. A good program has been arranged, and we believe every person present will thoroughly enjoy himself.

On account of the inclemency of the weather and the difficulty of transportation, no excursions have been held this year.

We wish to recommend that the Committee on Social Activities for 1920-21 be provided with sufficient funds by the Society to continue the work of promoting sociability and good-fellowship among the members.

The chairman wishes to acknowledge the hearty coöperation of the other members of the committee, A. W. Benoit, H. P. Eddy, Jr., R. W. Horne, D. Sutton and P. B. Walker, who have always been ready to help, and have contributed greatly to the success of the meetings.

Respectfully submitted,

CHARLES R. BERRY,

Chairman of Committee on Social Activities.

REPORT OF THE EDITOR.

TO THE BOARD OF GOVERNMENT, BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — The Editor submits herewith the report for the calendar year 1919.

There have been published 16 papers and 10 memoirs of deceased members.

Ten issues of 1250 copies each have been printed, comprising a total of 682 pages. The net cost of the JOURNAL was \$2 154.40, or \$3.16 per page. In 1918 the net cost was \$2 367.75, or \$3.22 per page. The somewhat more favorable showing for 1919 was brought about largely by keeping the number of cuts at a minimum and by an increase in the amount of advertising carried.

1919 JOURNAL.

Month.	PAGES OF			No. OF		Cost OF						
	Papers.	Proc.	Index, and other Unpaid Space).	Inseris.	Cuts.	Papers, Proc. and Index (inc. Stock for Adv. Pages).	Inserts and Cuts.	Adv.	Reprints.	Postage, Wrapping and Mailing.	Editing.	Inci. dentals.
Jan.	24	12	14	1	10	\$150.79	\$39.62	\$15.10	\$16.00	\$19.92		\$0.71
Feb.	42	10	14 ^{1/8}		3	199.54	45.57	27.01	23.00	18.90		8.16
Mar.	72	10	17 ^{3/4}		34	297.28	135.38	41.60	81.00	19.75		.27
Apr.	42	26	19 ^{2/3}			265.16		26.00	15.50	19.21		.52
May	54	14	19 ^{1/2}			247.44		22.93	27.18	19.34		
June	30	14	19 ^{1/2}		8	169.32		17.25	32.65	18.46		
Sept.	36	14	19 ^{1/6}		5	298.54	34.31	22.75	32.87	20.12		47.50†
Oct.	16	8	19 ^{1/4}			160.26	19.40	27.25	15.00	20.10		
Nov.	24	12	19 ^{1/4}			207.67		39.95	21.00	20.26		
Dec.	14	10	19 ^{5/6}			185.70		38.88	15.27	19.57	\$450.00	
Total	354	130	182+*	1	55	\$2 181.70	\$274.28	\$278.72	\$279.47	\$194.73	\$450.00	\$57.16
												\$10.00

Total gross cost..... \$3 726.06

Sale of JOURNALS and sub-
scriptions..... \$86.83

Advertisements..... 1 384.00

Reprints..... 100.83

\$1 571.66

Net cost.....

\$2 154.40

* 190 pages used, not all set solid.

† Cost of wrappers for mailing purposes.

At the close of the year the amount of paid advertising space was somewhat greater than at any previous time in the history of the JOURNAL.

In October our printers revised their figures in such a way as to increase the cost of the JOURNAL approximately fifty per cent. A canvass of other printers gave but little hope that the work could be done more cheaply elsewhere, so that we are apparently faced with this increased cost during the coming year.

Our advertising rates should be increased, if feasible, to absorb as much of this increased cost as possible. It is feared, however, that by so doing we may lose some of our present clients.

The advertising situation of the JOURNAL is a peculiar one, and cannot be viewed from a strictly commercial standpoint. Many advertisers have been carrying space for years without giving much thought to the matter, and these might be lost if their attention were arrested by an increased rate. It is probable, however, that rates could be raised at this time with less danger than at any previous time.

The appended table gives, in detail, figures of cost, number of pages, etc.

Respectfully submitted,

W. L. BUTCHER, *Editor*.

APPLICATION FOR MEMBERSHIP.

[April 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

CAMERON, EDWARD HUGH, Boston, Mass. (Age 31, b. Salem, Mass.). Graduate Mass. Institute of Technology, 1913, degree of S.B. in civil engineering, also a graduate of Lowell Institute in 1909, in mechanical engineering. Four years with H. P. Converse Co., as detailer, designer, estimator and superintendent of construction; two and a half years U. S. Navy, Public Works Dept., Submarine Base, New London, Conn., as chief draftsman and in charge of men of surveying work. Had charge of 21 men in the office and field, and supervised preparation of plans and field work for buildings, railroad tracks, paving, water supply systems, piers, etc. At present with Jackson & Moreland, civil engineers, Boston. Is an associate member, Am. Soc. Civil Engineers. Refers to E. P. Bliss, N. C. Burrill, J. W. Howard, L. B. Hoyt and L. J. Killion.

DAKIN, GEORGE WATERS, Boston, Mass. (Age 46, b. Boston, Mass.) Student at Mass. Institute of Technology, 1892, 1893, 1895 and 1896. Entered engineering service, sewer service, City of Boston, July, 1898, and has been continually employed in same service, as rodman, transitman, junior engineer, and since Jan., 1916, as district engineer with exception of about six months as sub-foreman on construction work, paving service of City of Boston, 1899. Has qualified under civil service for senior engineer. Now district engineer, sewer service, City of Boston. Refers to J. E. Carty, E. S. Davis, E. S. Dorr, G. W. Hamilton, E. F. Murphy and J. M. Shea.

GATELEY, FRANCIS JOSEPH, Boston, Mass. (Age 32, b. Boston, Mass.) Educated in public schools; three years civil engineering course at Franklin Union, 1914 to 1917, and buildings course at International Correspondence School, 1911-12. Rodman, sewer service, 1905-09; transitman, 1911-16, and in charge of party since 1916. Now resident engineer on Stony Brook work. Refers to T. F. Bowes, J. E. Carty, E. S. Dorr, G. W. Hamilton, E. F. Murphy and J. M. Shea.

HANNAN, WILLIAM ELLISON, Boston, Mass. (Age 46, b. Dorchester, Mass.) Graduated from Dorchester High School and then studied mathematics with tutor. With H. H. Moses, civil engineer, as rodman, 1891-92; in city surveyor's office, Boston, 1892-94, as transitman; with F. A. Foster as assistant in general engineering, 1894-96; from 1897 to 1917 in business for himself as engineer and surveyor; member Board of Street Commissioners, City of Boston, 1908 to 1911, and at present assistant engineer in Street Laying-out Dept. of Boston. Refers to W. H. Bacon, Arthur Howland, H. C. Mildram, F. M. Miner, J. E. L. Monaghan, E. F. Murphy and F. O. Whitney.

HENDERSON, WILLIAM DAVIS, Boston, Mass. (Age 30, b. Edgewater, Staten Island, N. Y.) Graduate Tufts College 1914, degree B.S. in civil engineering. From 1914 to May, 1917, with Mead-Morrison Mfg. Co., first as office assistant, contracting department, and later as superintendent of construction of coal handling plants; June to Sept., 1917, with Roberts & Shaefer Co., Chicago, as draftsman on design and details of coal mining plants; Oct., 1917, to March, 1920, with U. S. Navy Dept., at Submarine

Base, New London, Conn., in charge of work done by day labor in connection with the construction of the base; and since March, 1920, with Jackson & Moreland, civil engineers, Boston, as field superintendent in construction department. Refers to Conrad Nolan, E. H. Rockwell, F. B. Sanborn and J. A. Tosi.

HOLWAY, WILLIAM REA, Tulsa, Okla. (Age 27, b. Sandwich, Mass.) Graduate, Mass. Institute of Technology in 1915. With Providence Water Supply Board, 1916 and 1917; sanitary engineer at Alliance, Okla., July, 1917, to Jan., 1918; sanitary engineer, Tulsa, Okla., Jan., 1918, to Jan., 1920, and now consulting, civil and sanitary engineer, Holway Engineering Co., Tulsa, Okla. Refers to C. F. Allen, C. B. Breed, A. E. Burton, Dwight Porter and F. E. Winsor.

JOHNSON, WILLIAM ALOYSIUS, Dorchester, Mass. (Age 39, b. Boston, Mass.) Educated in public schools, graduating from Roxbury High in 1898, and took materials course at Franklin Union in 1910. Rodman in Street Laying-out Dept., Boston, 1898 to 1903; transitman in Sewer Dept., 1903 to 1906; junior engineer on Stony Brook Improvement, 1906 to 1909; junior engineer, Sewer Dept., 1909 to 1916; and since 1916, assistant district engineer, Sewer Dept. Refers to T. F. Bowes, E. S. Dorr, G. W. Hamilton, F. M. Miner, E. F. Murphy and F. O. Whitney.

LENNON, ARTHUR JAMES, Boston, Mass. (Age 32, b. Boston, Mass.) Educated in Boston public schools, member of Class 1912, chemical engineering, Mass. Institute of Technology, but left in 1910; and also has taken buildings course in Lowell School for Industrial Foremen. Appointed rodman in sewer service of City of Boston in 1910; transitman in 1912; superintendent of the Henry Spinach Contracting Co., 1914 to 1915; transitman, sewer service 1915-16; in charge of party, Strandway Improvements, 1916-18; highway division, 1918-19; junior engineer, sewer service, since June, 1919. Refers to B. F. Bates, E. S. Dorr, G. W. Hamilton, J. E. L. Monaghan and E. F. Murphy.

LONGFELLOW, GEORGE PERLEY, Boston, Mass. (Age 39, b. Haverhill, Mass.) Graduate Haverhill High School, 1900; and graduate of Haverhill Polytechnic Institute, Dept. of Engineering, 1903. On engineering service with engineers of Lawrence, Lowell and Haverhill, from 1903 to 1910; resident engineer Lockwood, Greene & Co. from 1910 to 1914; private engineering work from 1914 to 1918; on foreign service as Lieutenant U. S. Army, 1918 and 1919, and from Oct., 1919, to present time, resident engineer with Lockwood, Greene & Co. Refers to C. S. Allen, L. B. Ellis, E. R. Kimball, H. J. Reynolds, L. J. St. Amand and P. W. Taylor.

MONAHAN, LAWRENCE JOSEPH, Boston, Mass. (Age 51, b. Boston, Mass.) Educated in public schools, and course in structures at Franklin Union 1909-10. Has had twenty-five years' experience in engineering work and now assistant engineer, Street Laying-out Dept. of Boston. Refers to W. H. Bacon, Arthur Howland, H. C. Mildram, F. M. Miner, E. F. Murphy and F. O. Whitney.

O'CONNELL, JAMES PHILIP, Roslindale, Mass. (Age 50, b. Cambridge, Mass.) Educated in public schools of Cambridge and Cambridge Art School. Topographical and designing draftsman for City of Boston since 1890, except two years, 1896-97, with Metropolitan Sewerage Commission, and one year with Boston Elevated Railway Co., 1898, and since 1919, asst. engineer, Sewer Dept., City of Boston. Refers to E. S. Dorr, C. S. Drake, F. A. Lovejoy, R. J. McNulty and J. E. L. Monaghan.

LIST OF MEMBERS.

ADDITIONS.

HALL, W. W., Jr. 99 Salisbury St., Worcester, Mass.
 HOGUE, CHESTER J. 3734 Grand Central Terminal, New York, N. Y.
 ERNEST D. MORTENSON. Bedford, Mass.

CHANGES OF ADDRESS.

BEUGLER, EDWIN J.,

Vice-Pres. The Foundation Co., 233 Broadway, New York, N. Y.

BROWN, WILLIAM M. 128 Market St., Room 510, Newark, N. J.

COOMBS, ANTHONY S. 95 Monument St., West Medford 56, Mass.

DEMING, GUY S.,

Care Turner Construction Co., 11 Goodell St., Buffalo, N. Y.

FLETT, L. E., Care Lockwood, Greene & Co., 675 Park St., Hartford, Conn.

KENDALL, THEODORE R. 303 South Broadway, South Nyack, N. Y.

RESTALL, CHARLES H. City Hall, Springfield, Mass.

RICHARDSON, EDWARD B. 220 Devonshire St., Boston, Mass.

STROUT, HENRY E., Jr. 91 Wall St., New York, N. Y.

WELLS, CHARLES E. 568 West Main St., North Adams, Mass.

WOODS, WALTER A. 373 Washington St., Somerville, Mass.

RESIGNATIONS.

ACKERSON, HERBERT N.

ALLEN, LESLIE H.

BRADBURY, ROYALL D.

BROWN, H. WHITEMORE

BUSSEY, BYRON C.

CHARNOCK, FRED R.

DELONG, HAROLD C.

DOLLIVER, HENRY E.

EVERETT, FREDERIC E.

GRADY, WALTER J.

HOBSON, GEORGE F.

HOWLAND, CHARLES W.

HURLEY, HERBERT D.

KATZ, HARRY L.

LEAVITT, FREDERICK A.

MORRIS, FRANK H.

NEWMAN, ROLF R.

ROBINSON, ASHLEY Q.

SHERMAN, HERBERT L.

SMITH, RICHARD C.

SNOW, LESLIE W.

WALKER, ELTON D.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

- Bureau of Census.
- Transportation by Water, 1916.
- Statistics of Express Companies, 1918.
- Electrical Industries, Telephones, 1917.
- Tables of Mortality from Influenza and Pneumonia, in Indiana, Kansas and Philadelphia, Pa., 1917.
- National Forest Reservation Commission, Progress of Purchase of Eastern National Forest, January 1, 1920.
- Report of Director General of Railroads, February 28, 1920.

City and Town Reports.

- Brookline, Mass. Annual Report of Town Engineer for 1919.
- Hartford, Conn. Annual Report of Water Commissioners for 1918-1919.
- Lynn, Mass. Annual Report of Commissioner of Water Supply, for 1918.
- Philadelphia, Pa. Annual Report of Department of City Transit, for 1918.
- Plymouth, Mass. Annual Report of Water Commissioner for 1919.

Miscellaneous.

- Life of Leonard Wood, by John G. Holme. Gift of author.
- Leonard Wood on National Issue, compiled by Evan J. David. Gift of author.

LIBRARY COMMITTEE.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

**THE APPLICATION OF THE PERFORATING PROCESS
IN THE PRESERVATIVE TREATMENT OF WOOD
WITH ESPECIAL REFERENCE TO
DOUGLAS FIR.**

BY EDMUND M. BLAKE,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS

(Presented February 18, 1920.)

INTRODUCTION.

PERFORATING, as a process employed in the art of preserving wood, has been practiced in some form or other since the year 1838. Improvement in the method of perforating wood has been very slow. Even in recent years, up to about 1912, during which the preservative treatment of wood had shown rapid and marked development, the method of perforating had been practically neglected. As the use of more varied kinds of timber was necessitated, particularly by the railroads of the United States in order to meet their rapidly increasing annual tie requirements, timbers were encountered which did not yield to preservative treatment in the heartwood as easily as those which had first been used. Some heartwoods were even encountered which were so refractory in their resistance to preservative treatment, due to the peculiar nature of their cellular structure, that it was practically impossible to secure satisfactory penetration of the preservative, at least not without

* Production Engineer, Chas. R. McCormick & Co., St. Helens Creosoting Company, 900 Fife Building, San Francisco, Calif.

serious injury to the mechanical strength of the timber caused by overheating during treatment. When these conditions were encountered in commercial practice and the elements of obstruction to progress were recognized, the efforts of treating engineers were directed toward overcoming these obstacles.

While considerable progress had been recorded on the continent of Europe and in England between 1838 and 1912, a period of over seventy years, it was not until the latter year that scientific work along these lines began to shape itself definitely in the United States. In the meantime, in the treatment of railroad cross ties alone, the percentage of treated ties used in the total annual tie replacements on the railroads of the United States had increased from about 5 per cent. in 1901 to over 26 per cent. in 1912. From 1912 to 1917 important results in perforating were obtained from investigations and studies carried on in the United States. Then the European War intervened, scientific investigations outside of the urgent necessities of the war were practically abandoned and no commercial progress was made in the method of perforating. Within a few months after the signing of the armistice, the attention of treating engineers was again centered upon this important matter, and to-day machinery for the mechanical application of the perforating process is under construction and will probably be extensively used in various parts of the United States before the close of 1920. As soon as this machinery for adapting the process of perforating to the art of preserving wood is available, it is confidently expected that the scientific development of this process will be very rapid in connection with all kinds and sizes of heartwood timber.

HISTORY OF THE PERFORATING PROCESS,

While the available records of ancient times show that the art of preserving organic bodies against decay and the protection of timber from attacks by worms were known and practiced as far back as the period during which Pliny* lived, and that various forms of preservation were used by the early Egyptians, Greeks, Britons, Dutch and Burmese, the preserva-

* 23 to 72 A.D.

tion of wood by the injection of preservative liquids did not become scientific in principle until early in the nineteenth century. Many authentic records, however, showing the gradual development of the art of preservation of timber, are available covering the period from 1657 to 1838, in which latter year Bethell patented a process for using coal tar creosote which was injected into the wood under pressure in a cylinder. It was also in the year 1838 that the first cross ties were treated in the United States for use on the Northern Central Railroad in Maryland, now a part of the Pennsylvania System. Previous to 1838 Kyan had patented an injection of a preservative into wood by pressure in a closed cylinder in 1832, and Moll had patented a process for treating wood with coal tar creosote in a closed iron vessel in 1836.

So far as the records which have been examined indicate, the first definite method of perforating timber, as an aid in the injection of preservatives, dates back to the year 1838, when a patent was granted to Earle, No. 934, on September 20 of that year. While it is recorded that Carey experimented in perforating wood before introducing the preservative in 1829, little is known of the method employed by him. In the Earle process, holes were bored axially through the timber. It is obvious that these first attempts at perforating were made on account of the obstructions encountered in the cellular structure of timber which retarded the impregnation of the preservative material under the crude processes employed during the early development of the industry.

In 1848 wood preservation was first started on a commercial scale in the United States at Lowell, Mass.

The perforating of wood by the use of holes extending radially into the timber is first indicated in the "Proceedings of the Institution of Civil Engineers," published in London in 1852 and 1853, in which the opinion is stated that when it is desirable to expedite the process of saturating wood with essential oils, it is necessary to puncture the timber with numerous small holes.

In 1875 the Louisville & Nashville Railroad built a treating plant for the commercial use of the Bethell process which laid

the foundation for the modern timber treating industry of the United States.

Following the patenting of the Rueping process in Germany in 1902, and in the United States in 1904, the development of wood preservation was very rapid, and approximately forty-five treating plants were built in this country during the period from 1902 up to 1908.

Practically all of these plants used the pressure process. Their rapid installation, indicating even more rapid increase in the demand for treated material, gave little or no time for experimental investigation of practical methods which would insure more uniform penetration of the preservative and expedite its impregnation.

It was, therefore, quite natural after all of these plants had been constructed and were in operation, together with many more plants installed in the period from 1908 to 1913, that the attention of treating engineers should again become centered upon improvements in the art of preserving wood, especially along those lines which would result in better penetration, less preservative, and reduction in the time of treatment.

On December 24, 1907, an application for a patent on a perforating process was made in the United States by Archibald R. Whitehead, an English inventor. The complete specification covering this patent was filed on June 11, 1909. The records do not show that this patent was actually granted in the United States, although the application was accepted on October 15, 1908. British creosoters had found that it was impossible to impregnate the inner portion of the heartwood of railway sleepers and telegraph poles. Whitehead stated that the oil enters the tubular cells of the heartwood at the two ends of the piece of timber undergoing treatment and flows along them for a short distance, varying in length according to the amount of pressure applied, but fails to gain admission through the lateral walls of the cells. He proposed to make a series of borings or incisions in the heartwood across the grain in such a manner as to divide each line of tubular cells into lengths short enough to allow the preservative to reach every part of its length. In order to avoid unnecessary perforations, Whitehead

proposed that each line of tubular cells should be pierced at intervals as nearly as possible equal to twice the length that the preservative would flow along such cells. The Whitehead perforations were to be arranged zigzag, not opposite to each other, and were intended only as channels or ducts leading to the cells, and he expected that the timber so perforated would not be impaired in strength, usefulness or appearance.

Two patents covering a method of perforating timber were granted in the United States to Kolossvary, Haltenberger and Berdenich, Austrian inventors from Budapest. The first one, No. 1012207, was granted December 19, 1911, and the other No. 1018624, on February 27, 1912. These two patents cover what is commonly known as the Haltenberger Process, under which experiments had been carried on in Austria since 1906. In this process the perforations in the timber were made by revolving piercers or needles which do not remove any part of the fibers of the wood, as by boring, but simply push them aside. This process was developed for use on round sticks of timber, such as telegraph and telephone poles, and the perforations made by the piercers extend in a line around the stick and are arranged in left-handed spirals.

While Rueping and others had already introduced economical methods of decreasing the cost of treatment in the case of spongy and easily treated woods, Haltenberger was trying to effect the same economy in the impregnation of harder woods and particularly of what we term the heartwood of timber. By the use of his piercers, Haltenberger created an artificial intercellular system by which he expected to regulate the results of impregnation even when the wood under treatment originally possessed intractable qualities.

On October 3, 1913, a German patent on the perforating process, No. 281793, was granted to Mr. Max Rueping.

On November 9, 1916, an application was filed in the patent office at Washington, D. C., by Oliver P. M. Goss, of Seattle, covering his claim as the inventor of an improvement in the art of preserving wood. Mr. Goss was engaged in consulting work for the Association of Creosoting Companies of the Pacific Coast at the time of the filing of this application. The Asso-

ciation was comprised of the following commerical treating companies: the Pacific Creosoting Company, Eagle Harbor, Wash.; the J. M. Colman Company, Seattle, Wash.; the St. Paul and Tacoma Lumber Company, Tacoma, Wash.; the Columbia Creosoting Company, Linton, Ore.; and the St. Helens Creosoting Company, St. Helens, Ore.

On June 15, 1917, a co-ownership contract was entered into between Mr. Goss and these five companies under which they acquired a one-half interest in his invention and any letters patent which might later be granted to him. Mr. L. J. Colman was made trustee for all of the co-owners.

On January 8, 1918, letters patent No. 1252428 were granted to Mr. Goss.

On April 26, 1919, notices were sent to the railroad and commercial treating plants of the United States over the signature of L. J. Colman, trustee, stating that he was prepared to license the use of the perforating patent at a royalty of one-half cent per cross tie and 15 cents per thousand board feet of lumber.

Serious and weighty opposition to the payment of any royalty charges under the Goss patent developed shortly after this announcement was made. Many conferences were held between the co-owners of the patent and by them with the representatives of several of the railroad treating plants. Chas. R. McCormick & Co., of San Francisco, managing operators of the St. Helens Creosoting Company, became convinced that the interests of the Douglas fir industry and the commercial creosoting plants of the Pacific Northwest would be best promoted by the elimination of all royalty charges under the Goss patent and promptly took the initiative with the object of bringing about this result. Their efforts were finally successful, and on October 6, 1919, all of the rights of Mr. Goss were acquired by the following companies and by them were dedicated on the same date to the public for general use free of cost: Pacific Creosoting Company, J. M. Colman Company, St. Helens Creosoting Company, Chas. R. McCormick & Co., St. Paul and Tacoma Lumber Company, Columbia Creosoting Company.

On December 12, 1919, a second notice was mailed by

L. J. Colman, trustee, to the railroad and commercial treating plants of the United States, canceling the notice of April 26, 1919, and stating that the Goss patent had been dedicated to the public use on October 6, 1919.

EXPERIMENTAL WORK.

In 1902 the Rueping process patents were taken out in Germany, the rights being held by Huelsberg & Co. At the request of the Santa Fé road, this company sent a representative to the United States in the fall of 1903 for preliminary experiments with a view to adopting that process in this country. In 1904 the Rueping patents were granted in the United States and in the same year this process was exhibited at the St. Louis Exposition. In the spring of 1905 Huelsberg & Co. sent Mr. B. Kuckuck over, under arrangements with the Santa Fé, and ties treated by him with the Rueping process were placed in Santa Fé tracks in that year. Mr. Kuckuck made another trip to this country in 1906 and, following the adoption of the Rueping process by the Santa Fé road, established his residence in this country about 1910, supervising the work at Somerville, Tex., on the adaptation of the Rueping process to American practice.

It was about this time that Douglas fir cross ties were beginning to be used in large quantities by Western railroads, and no satisfactory method of treating them had been found. The temperatures required to secure even partial penetration of the oil were so high that the strength of the material was seriously impaired in treatment. By reason of their great mechanical strength and durability, however, several trans-continental railroads wished to use Douglas fir ties in parts of their Western lines, and therefore centered their attention on evolving a satisfactory method of treatment. Arrangements were made with the St. Helens Creosoting Company at St. Helens, Ore., and a series of experiments were started at that plant in May, 1912.

Mr. Kuckuck, Mr. George E. Rex of the Santa Fé, Mr. Lowry Smith of the Northern Pacific, and several other treating engineers were present at St. Helens when the test ties were

taken from the water. The results were not satisfactory with the water seasoning and, in attempting to find another solution of the problem, Mr. Kuckuck made the suggestion for the first time that perforating the ties might produce the desired results.

In September, 1912, Mr. Kuckuck, in a conference with Mr. E. O. Faulkner of the Santa Fé at Los Angeles, on the refractoriness of Douglas fir and the proposed experiments at St. Helens, suggested the possibility of using the Haltenberger perforating process which he thought might result in securing the desired penetration.

In the latter part of September, 1912, experiments were made at Albuquerque, N. M., Alamogorda and Somerville, Tex., by Mr. Kuckuck, in perforating cross ties by the use of nails and other instruments. Mr. J. L. Campbell, chief engineer of the El Paso & Southwestern Railroad, was convinced of the correctness of the principle of perforating at this time. Cross sections of some of these ties were sent back to Los Angeles with a letter from Mr. Kuckuck stating that the results were most encouraging.

In December, 1912, Mr. Kuckuck sent Mr. Faulkner a descriptive circular of the Haltenberger perforating process, and in September, 1913, sent him the complete papers and diagrams on that process.

In May, 1913, Mr. Kuckuck was placed in full charge of the experiments to be conducted at St. Helens, Ore., and in August of that year treatment tests were made on the air and water seasoned Douglas fir ties in the presence of the following gentlemen: Mr. George E. Rex, Mr. Lowry Smith, Dr. Hermann von Schrenk, Mr. F. S. Pooler, Mr. J. F. Pinson, Mr. V. C. Smith of the British India Railways, Mr. Charles Adams, Mr. Alex. Lupfer and Mr. O. P. M. Goss, then in the United States Forest Service. With Mr. Kuckuck were Mr. F. D. Beal, manager, and Mr. R. H. Rawson, superintendent, of the St. Helens Creosoting Company. During the course of the experiments several of the charges contained half ties perforated on all four sides by the use of drills and other puncturing devices, with varied spacing of the holes, and Mr. Kuckuck went so far as to plot diagrams showing the spacing as suggested by him. During these tests both Mr. Beal and Mr. Rawson worked in conjunction

with Mr. Kuckuck in the investigation of the possibilities of perforating cross ties. The results obtained were again very encouraging.

In September, 1913, tests were conducted on perforated ties at Toledo for the Lake Shore Railroad; in November, 1913, at Patterson for the D. L. & W. R.R., and in March, 1914, at Adelaide for the P. & L. E. R.R.

In 1914, from April 1 to 16, experiments were conducted at St. Helens under the supervision of Mr. Goss, then with the West Coast Lumbermen's Association and the Association of Creosoting Companies of the Pacific Coast. During these experiments cross ties were perforated before treatment and later strength tests were made to determine the effect of the perforation.

In 1914, before returning to Germany, Mr. Kuckuck drew up complete plans and specifications for the application of the perforating method to cross ties, leaving copies in this country, and making application for a patent covering the Haltenberger process, the German rights on which had been purchased by Mr. Max Rueping to cover the perforating of cross ties.

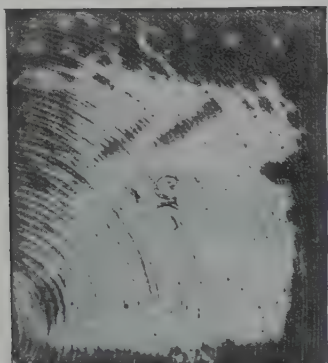
In November, 1915, representatives of the railroad treating plants and timber men, including Mr. Goss, then consulting engineer for the West Coast Lumbermen's Association, again met at St. Helens, Ore., and during this conference, which was held largely to discuss the results of the 1913 and subsequent experiments, perforating was considered as the probable solution of the Douglas fir problem, and every one agreed that this method was the only one by which a satisfactory treatment could be secured. No practicable mechanical application of the method, however, had been reached at that time.

The "Clark Machine," for perforating ties, was built late in 1915 and it was believed by the treating engineers who saw it in operation that the basic principle of the mechanical application of the perforating process had been developed by the Columbia Creosoting Company in this machine, i. e., by some form of teeth inserted in revolving drums. This machine was used in both experimental and commercial work, and again the results were very encouraging, but the consensus of outside opinion was that these results were still far from satisfactory.

In December, 1915, perforating experiments were carried on by the Pacific Creosoting Company at Seattle, in which three forms of wedges and one spike were used in making the perforations. Various arrangements of the holes were tried, the penetration being about three quarters of an inch. As only a small number of ties were used in these tests, definite conclusions could not be drawn, but very satisfactory results were indicated.

During the winter and spring of 1916, Douglas fir ties were perforated and treated in the experimental cylinder of the Northern Pacific Railroad at Paradise, Mont., and sent to Mr. Goss for compression tests perpendicular to the grain at the laboratory of the University of Washington at Seattle. These tests were made in May and July, 1916. As the temperatures used in treating the first set of ties were too high, a second set of ties were perforated and treated at a lower temperature. The tests made on this second set of perforated ties showed a strength in compression perpendicular to the grain of about 90 per cent. of the strength of the untreated tie, which indicated a combined loss of about 10 per cent., due to perforating and treatment. The perforations made in these ties were five eighths of an inch long, one eighth of an inch wide and three quarters of an inch deep, so located as to obtain a lapping of the longitudinal penetration and resulting in a solid treatment to the depth of the perforations. It was found necessary to use a chisel point that would cut the fibers the width of the tooth, otherwise the perforations would close up while being treated, seriously retarding penetration. Mr. Goss later made a series of independent tests in connection with the work done for the Northern Pacific. Figs. 1, 2 and 3 show the effects of perforations on the penetration of creosote in Douglas fir timber.

In June, 1916, tests were made at the University of Kansas on the feasibility of perforating timber by means of high voltage electricity. It was found that when the tie was placed between contacts, between which an arc was maintained in air, the area around the contacts was covered with a brush discharge which extended over the surface without producing any puncture as the voltage was raised. The conclusion was reached that such a method could not be applied practically to the perforation of timber, and these tests were abandoned.



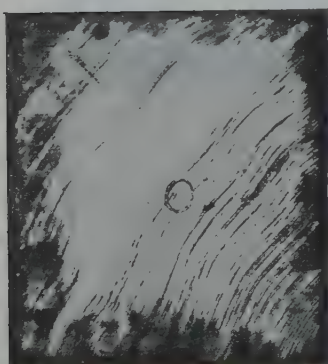
PERFORATED.



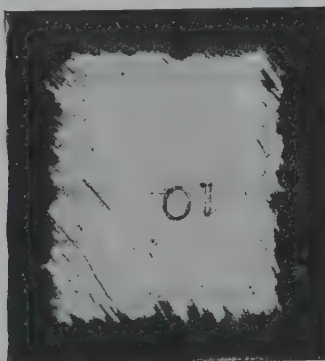
NOT PERFORATED.

FIG. 1.—PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR CROSS TIE.

Both treated in same charge during experiments in 1916.



PERFORATED.



NOT PERFORATED.

FIG. 2.—PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR CROSS TIE.

Both treated in same charge during experiments in 1916.

In 1917 a set of 4 x 4 ins. Douglas fir sticks, treated at the Forest Products Laboratory, Madison, Wis., by the Rueping process, were tested for strength, these tests being made to show the effect of perforations and treatment on the strength of the wood. Half of the sticks were perforated to a depth of about three

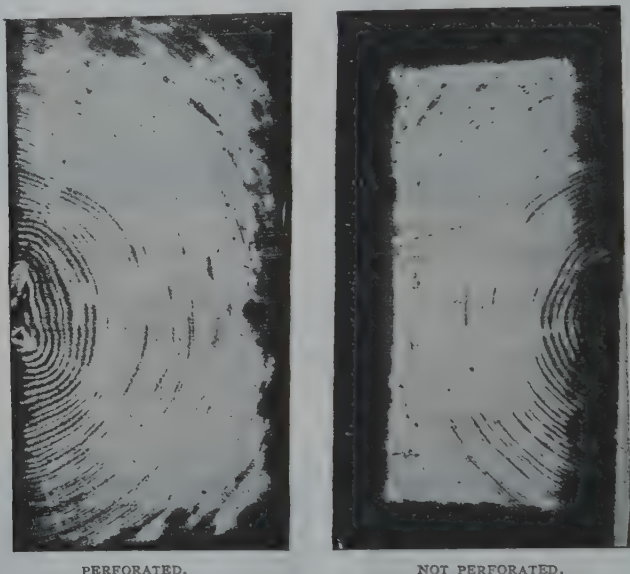


FIG. 3.—PENETRATION OF CREOSOTE IN TWO PIECES OF SAME DOUGLAS FIR TIMBER.

Both treated in same charge during experiments in 1916.

quarters of an inch, the holes being arranged in diagonal lines one half of an inch apart transversely and 7 ins. apart longitudinally. The penetration in the perforated sticks was complete to the depth of the holes. The unperforated sticks treated at the same time showed the usual variability and uneven penetration characteristic of Douglas fir. The completion of these experiments was interrupted by the war and no final report has yet been made upon them.

The foregoing does not pretend to be a complete chronicle of the experimental work done in the past on the perforating of

wood before treatment, but the experiments and tests recorded therein cover the principal work done along that line, which had, as its direct object, the finding of a satisfactory method of preparing Douglas fir for preservative treatment in such a way as to insure uniformity of penetration and the reduction of both high temperatures and length of treatment in the retorts with their resulting injurious effect upon the strength and durability of the wood.

MECHANICAL DEVICES.

The first machine built in the United States for the mechanical application of the perforating process was designed and constructed at the Willamette Iron Works, Portland, Ore., during the latter part of 1915 for the Columbia Creosoting Company, and was erected and placed in operation at their plant near Portland. It was quite extensively used by that company in the perforation of railway sleepers for export to the Orient in 1916 and 1917 and was also used in experimental work.

The machine consists of two horizontal and two vertical drums, in the surfaces of which are set permanent V-form rows of puncturing points. Four spiral springs hold one each of the horizontal and vertical drums against the tie as it is passed through the machine in the same general manner in which lumber is passed through a planer. The machine is operated by electricity at a speed of approximately 70 lineal feet per minute.

So far as records are available it appears that nothing further was done in the development of the mechanical application of the perforating process until October, 1919, when the Goss patent was dedicated to the public.

On December 16, 1919, a conference was held at Chicago between Mr. D. W. Edwards, of Greenlee Brothers & Co., and Messrs. George E. Rex, Lowry Smith and Edmund M. Blake, to perfect the details of the design for a new perforating machine. An order was placed the next day by Chas. R. McCormick & Co., of San Francisco, for the first machine, to be built at Rockford, Ill., for delivery in May, 1920, to the plant of the St. Helens Creosoting Company at St. Helens, Ore.

The Greenlee machine (Fig. 4) will be of particularly rugged design in view of the fact that it is to be operated under extremely severe mechanical conditions of unskilled labor, variation in the quality and sizes of woods to be perforated, the encountering of knots and more or less exposure to the weather.

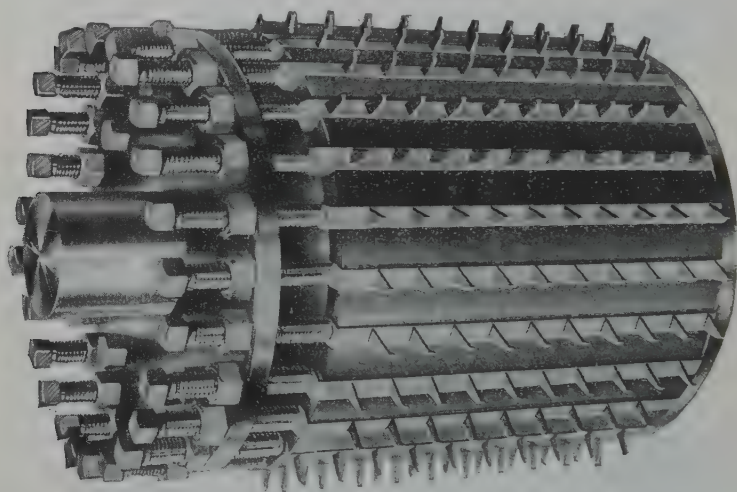


FIG. 4.—VIEW OF ONE OF THE FOUR DRUMS OF THE GREENLEE PERFORATING MACHINE.

Showing teeth and set-screw arrangement for adjusting the same. Speed of drum in operation about 70 linear feet per minute. Tooth centers $1\frac{1}{2}$ ins. transversely, 2 ins. longitudinally, offset to perforate in diagonal lines.

The maximum size capacity of the machine will be for ties and timber up to 8 ins. in thickness by 14 ins. in width, the minimum thickness to which the machine will work being 3 ins. and the minimum width being 6 ins. Timbers and ties, therefore, varying from 3 x 6 ins. to 8 x 14 ins. can be perforated by this machine.

It will have a massive main frame on which will be mounted 4 perforating rolls or drums, 2 horizontal and 2 vertical. The diameter of all the drums will be $14\frac{1}{2}$ ins. The width of available tooth spacing in the horizontal ones will be 14 ins., and in the vertical ones 8 ins.

The lower horizontal drum and the right-hand vertical drum, looking in the direction in which ties and timbers will be fed into the machine, will be located rigidly and both will be driven by gearing mounted upon the side of the machine arranged to receive its power from a 10-h.p., 3-phase, 60-cycle, 440-volt, A.C. motor.

The top horizontal drum and left-hand vertical drum will be flexibly and adjustably mounted for variations in the tie and timber sizes, and will furthermore be provided with flexible connections which will permit of a rocking or tilting position for perforating ties of more or less irregular form. The approximate variation of adjustments and provision for play so arranged will amount to about one half of an inch.

In addition to the four principal drums there will be provided a counterweighted, or spring actuated pressure roll, power driven from the same motor and adjustably hinged in front of the horizontal drums as an aid to the operator in lining the ties up against the rear fence as they are fed into the machine, thus assuring a straight and true feed.

The two adjustably-mounted drums will be fitted with heavy coil springs provided with tension adjustment arranged to give the necessary force to the drums for properly performing their perforating functions. The maximum pressure provided for in these springs will amount to 25,000 lbs.

Each drum will contain 25 toothways arranged to carry the teeth for perforating on approximately 2-in. distances lengthwise of the timber. The teeth will be placed in these toothways with spacing blocks for $1\frac{1}{4}$ -in. tooth centers. The tooth spacers, or wedges, will be of mild steel and the teeth of hardened and tempered tool steel, designed to project seven eighths of an inch from the surface of the drum. The face of the drums will be in contact with the ties and timbers as they are passed through the machine so that the teeth will penetrate into the wood the full length of their projection from the surface of the drums.

The principal bearings of the machine will be of cast iron scraped to a smooth and perfect fitting surface, with shafts and bearings provided with oil grooves. The bearings will be fitted

with dust protecting devices and extra heavy compression grease cups of large capacity. The roll or drum shaft, on which the drums are operated, will have a diameter of 4 ins.

The speed of the machine will be about 70 lineal feet per minute, which will permit the perforating of 8 ties 8 ft. in length per minute, or about 3 800 ties in eight hours.

FORECAST.

The annual cross tie requirement on the steam railroads of the United States reached the large total of approximately 119 500 000 pieces in 1916. If the annual requirements of the electric lines and private industrial tracks were added, the total would be approximately 133 500 000 pieces, representing annually over 5 000 000 000 board feet of timber. Furthermore, the number of ties treated in 1916 amounted to over 28 per cent. of the total number used. Both the production and treatment of cross ties in 1917, 1918 and 1919 were affected by the conditions brought on by the entrance of the United States into the European War. There appears to be no doubt, after business is restored to normal conditions, that the percentage of treated heartwood ties will rapidly increase, especially in view of the apparent increase in the cost of high-grade untreated ties suitable for main line use. This will call for a steadily increasing annual quantity of creosote oil and other preservatives.

During the early years of American practice, ties with a large proportion of sapwood were purchased, and zinc chloride was quite generally used as a preservative. As the cost of ties increased, a better treatment was demanded, but when creosote was introduced on a large scale the sapwood absorbed so great a quantity of the oil that creosoting under the old processes was not economical because the amount of creosote injected would preserve the tie from decay much longer than its mechanical life. This fact and the relatively limited amount of creosote oil available in this country and abroad brought American treating engineers face to face with the problem of its restricted use. Through the efforts of Mr. E. O. Faulkner of the Santa Fé Systems, the Rueping process was introduced into American practice in 1905 whereby the conservation of creosote oil became

an accomplished fact. By this process the amount of creosote oil consumed per cubic foot of timber treated can be limited to that which is required to preserve the tie throughout its mechanical life.

The next problem was that of developing a method of treating the tie with a minimum reduction in its natural strength and durability, so that its maximum mechanical life could be obtained. Here the investigators were confronted early in their experiments with the necessity of running charges through the retorts at high temperatures in order to properly impregnate the wood, with the result that the natural strength and durability of the tie was reduced from 30 to 40 per cent. during treatment. In some cases it was found that even high temperatures did not result in satisfactory impregnation on account of the refractoriness of certain woods.

The problem, therefore, became one of preparing the tie for treatment in such a way that the high temperatures and the time required for treatment in the retorts could be reduced.

It is confidently believed that the perforating process, scientifically carried out as to spacing, depth and shape of the perforations, will solve this latest problem, which at the present time confronts the treating engineers of this country, by making possible a reduction of temperature and time of treating.

It is erroneous to suppose that because the experiments on the perforating process have been largely conducted in the Pacific Northwest on Douglas fir, the value of perforating is applicable only to that timber. Obviously it will apply as well to the heartwood of any kind of timber in which it is now impossible to secure satisfactory penetration of preservative oils.

Furthermore, perforating is applicable as well to lumber for practically every use (except that in which it is subjected to loading in tension or shear), such as lumber for switch ties, sheathing, bulkheading, pontoons, marine railways, bracing, mining timbers, cross arms, sewer outfalls, culverts, etc.

Perforating can also be used on round, tapering sticks, such as poles and piling, and studies have already been started on the design of machinery to accomplish this purpose with timbers of that shape.

Its application to structural timbers for use in bridges and other structures, in which the beams are subjected to loading in tension or shear, can only be settled after thorough investigation of the effect of the perforating holes upon the tensile and shearing strength of the timber.

To summarize briefly, it is expected that perforating before treatment will accomplish the following results:

1. Control, reduction or complete elimination of checking in green ties and timber if perforating is done promptly after cutting.
2. Reduction of the temperatures required to secure satisfactory impregnation.
3. Reduction of the time required to treat ties and timber in the retorts.
4. A complete and uniform penetration of the preservative to the depth of the perforations.
5. Reduction of not over 8 to 10 per cent. in the strength of the timber in compression perpendicular to the grain. This means a reduction of the present loss in the strength and mechanical life of the treated unperforated ties or timber, which varies from 30 per cent. to 40 per cent. to a point which will balance the cost of treatment to the satisfaction of the demands of track maintenance engineers.

SOME FACTS ON DOUGLAS FIR—PARTICULARLY ON THE PRODUCTION OF DOUGLAS FIR CROSS TIES.

The Pacific Coast states, California, Oregon and Washington, cover an area of approximately 317 420 square miles with about 1 400 miles of coastline measured on navigation lines. In comparison, the combined areas of Illinois, Missouri, Iowa, Wisconsin, Michigan and Kentucky amount to about 332 090 square miles, and the combined areas of Alabama, Louisiana, Arkansas, Tennessee, Georgia and Mississippi amount to about 297 075 square miles. The rainfall in the three Pacific Coast states shows the greatest variation of any similar area in the United States, ranging from as high as 137 ins. annually west of the Coast Range Mountains in Oregon and Washington to

less than 12 ins. annually in southeastern Washington, central and eastern Oregon, and in the Mojave Desert and Death Valley districts of southern California. Very little snow falls and freezing temperatures seldom occur west of the Cascade and Sierra Nevada Mountains from the British Columbia line to the Mexican frontier, except in the mountain districts above an altitude of about 5 000 ft., and except at intervals of many years in the areas of lower altitude such as came during the severe storms of November and December, 1919, around the Portland district, when the Willamette River was frozen solid for the first time in the memory of the oldest inhabitants. During that storm lumber and logging operations were seriously crippled, but such extreme conditions are very rare in occurrence.

The timber stands along the Pacific Coast lie in condensed areas with quite a demarkation between the different kinds of wood, and are located approximately as follows:

Douglas fir is found, generally in very dense stands and of large sizes, running from the coast lines of Washington, Oregon and the northern half of California back to and in some cases east of the Cascade Mountains, most of the growth coming in the area of heavy rainfall. In the northern half of California it is less dense, and lies in the growth of redwood. It is also found in northeastern Washington and the eastern district of Oregon, where it is commonly known as mountain fir, and along the slopes of the Sierra Nevada Mountains in California.

Spruce is found principally in a comparatively narrow belt running along the western portions of Washington and Oregon about 20 miles inland from the coast.

The stands of white and sugar pine lie along the slopes of the Sierra Nevada Mountains running south from the Klamath Falls district in central Oregon down into the Bakersfield district in southern California.

Redwood is found only in California, with the exception of a small amount scattered in the growth of Douglas fir along the coast in southern Oregon. It appears in two forms. The stands of the variety known as *Sequoia sempervirens* occur along the coast running from the Oregon line down to the Santa Cruz district on Monterey Bay, in what is known as the "fog

belt," requiring excessive moisture for proper growth. The variety known as *Sequoia gigantea* grows in the district east of Merced along the western slopes of the Sierra Nevada Mountains, of which district the Yosemite Valley is a part. In this latter growth are found the largest trees of the world, one of which, known as the "General Sherman," is 283 ft. high, 25 ft. in diameter at the ground, and 17.7 ft. in diameter 100 ft. above the ground, the first branch being 20 ft. in circumference.

Cedar is found principally in the western portions of Oregon and Washington and scattered along the slopes of the Sierra Nevada Mountains. Western red cedar, found in Washington, is the largest of the four true cedars in the world. Port Orford cedar is widely known for its great beauty and is found in the Coos Bay district of Oregon.

Many areas of Douglas fir, redwood, spruce and pine have not yet been touched or made accessible to logging operations. This is particularly true of the stands of Douglas fir and spruce on the Olympic Peninsula in Washington, which is the area west and northwest of Tacoma. It is also true of a large part of the Douglas fir and spruce stands lying in Oregon between the Coast Range Mountains and the Pacific Ocean, especially along the Siletz and Wilson rivers. During the past year extensions of old logging roads and new logging roads have been started, in addition to those which were constructed during the war.

THE TIMBER RESOURCES OF THE PACIFIC COAST STATES.

Based upon the most reliable information obtainable, there are in the United States to-day probably about 550 000 000 acres of standing forest, including both privately owned and public lands. Of this total there are about 80 000 000 acres in the Pacific coast states of California, Oregon and Washington. Although this is a relatively small percentage, on these 80 000 000 acres it is estimated there are about 1 300 000 000 000 board feet of standing timber, which is approximately one half of the remaining supply of standing timber in the United States. About one half of this quantity, or 630 000 000 000 board feet, is Douglas fir, representing about one quarter of the total timber stand in the United States to-day.

Of the total of 1 300 000 000 000 board feet, about 340-000 000 000 are found in the state of California, about 510 000 000 000 in the state of Oregon, and about 450 000 000 000 in the state of Washington. It is interesting to note in comparison that the total stand of yellow pine in the southern states to-day, based upon figures recently compiled, is probably not much in excess of 225 000 000 000 board feet.

The following figures give an approximate idea of the relative stands in 1920 of the various kinds of timber in the Pacific coast states:

Timber.	Location.	Billions of Board Feet.
Douglas fir.....	California.....	65
	Oregon and Washington.....	565
Redwood.....	California — coast.....	75
White pine.....	California and southern Oregon.....	120
Sugar pine.....	California and southern Oregon.....	35
White fir.....	California and southern Oregon.....	40
Cedar.....	California and southern Oregon.....	10
Other species.....	California and southern Oregon.....	10
Spruce.....	Oregon and Washington.....	50
Cedar.....	Oregon and Washington.....	60
Hemlock.....	Oregon and Washington.....	85
Western yellow pine.....	Oregon and Washington.....	125
Western larch.....	Oregon and Washington.....	20
Other species.....	Oregon and Washington.....	40

Total stand, estimated.....1 300

In connection with the stands of Douglas fir, the following table shows the proportion of public and privately owned stumpage:

DOUGLAS FIR — ESTIMATED STANDS IN 1920.

Location.	Billions of Board Feet.		Total.
	Public.	Private.	
California.....	20	45	65
Oregon and Washington	98	467	565
Totals.....	118	512	630

The present relation between the annual production of lumber and the resources of the Pacific coast states gives an

indication of the future possibilities of that district. The three states combined, in 1918, produced about 8 500 000 board feet, and in 1919 about 8 800 000 board feet. The estimated total lumber production in the United States for 1919 is placed at about 30 000 000 000 board feet as against about 32 750 000 000 in 1918, and 36 000 000 000 board feet in 1917. The recent shortage is said to be principally in the southern pine output. The normal annual lumber export total from the Pacific Northwest is approximately 600 000 000 board feet, but the total exported in 1919 was probably less than 400 000 000 board feet, this reduction being accounted for by the conditions brought on by the war and the acute shortage of available tonnage.

It is interesting to note that the lumber mills and logging camps of Oregon and Washington gave employment to over 80 000 men during 1919, and the total pay roll amounted to about \$120 000 000.

THE RELATION BETWEEN CROSS-TIE PRODUCTION AND THE LUMBER INDUSTRY.

There may be some misconception in the minds of tie manufacturers east of the Rocky Mountains as to the relation of tie production to the lumber industry of the Pacific Coast. In the southern states along the valley of the Mississippi River, in the north central states and in the east, where probably over 90 per cent. of the annual requirements in cross ties has been produced in the past, a large portion has been cut by companies organized for that purpose, whose principal business is the manufacture of cross ties. These companies vary from the larger concerns which handle the output of many tie-producing areas down to the small local companies. Large quantities of hewed ties have also been cut by individuals. In other words, in the districts east of the Rocky Mountains, tie production is quite generally a distinct and separate business by itself, although a great many ties are produced in connection with mills whose principal output is lumber in other forms.

West of the Rocky Mountains, in the states of California, Oregon and Washington, the conditions are practically reversed.

The manufacture of cross ties on the Pacific Coast up to the present time has been largely incidental to the lumber business. While the number of hewed cross ties produced annually on the Pacific Coast is small in comparison with the number of sawed ties, still a large number of split and hewed redwood and hewed fir ties are produced each year outside of the mills. There are also many tie sawmills in the Lewis River district of southern Washington and along the Willamette valley in Oregon. The tie situation, however, has been principally a lumber-mill problem of secondary importance, and the amount of future production of cross ties will depend largely upon the attitude of the lumber mills toward the manufacture of this particular railway timber product. This, in turn, will depend upon the specifications, inspection rules and prices controlling the transactions.

The production of cross ties on the Pacific Coast in 1919 probably only represented from 6 to 7 per cent. of the total lumber production, from which it is evident that cross ties to-day are a relatively small incident to the lumber industry. Probably over 90 per cent. of the Douglas fir ties manufactured on the Pacific Coast are sawed in lumber mills from logs of large dimension, because the average stand of Douglas fir trees is of large size and it has not paid to log the smaller trees except for use as piling. Therefore, the conditions and problems which are encountered in the production of cross ties on the Pacific Coast to-day are quite fundamentally different from those which influence the tie situation east of the Rocky Mountains.

DOUGLAS FIR TIES.

The principal sources of supply of Douglas fir ties are as follows:

Washington: In the Bellingham and Everett districts on the Olympic Peninsula, in the Grays Harbor and Willapa Harbor districts, in the Lewis River district of southern Washington, along the Columbia River, and in general back to and occasionally east of the line of the Cascade Range of mountains.

Oregon: Along the Columbia River, in the Coos Bay district, along both sides of the Willamette River, and generally

in the west central areas of the state from the Willamette River to the coast line.

California: In scattering areas along the coast from the Oregon line nearly to Santa Cruz, in the Mt. Shasta region of north central California, and along the slopes of the Sierra Nevadas as far south as the Yosemite Valley district.

In connection with the use of Douglas fir it is interesting to note that the great durability and resistance to saturation by water of Douglas fir, and its great mechanical strength combined with its lightness in weight, particularly fit it for use in the form of cross ties. The unusual refractoriness of its cellular structure has, in the past, tended to limit the treatment of the heartwood with creosote oil or other preservatives, but the recent development and perfection of the mechanical perforating process assures a greatly increased use of treated Douglas fir in cross ties in the future. Douglas fir also grows very large in size and very dense in stand, and the number of hewed ties is very small, most fir ties being sawed from the logs. Structural timbers 18 x 18, running from 120 ft. to 140 ft. in length, and timbers as large as 36 x 36 and even 46 x 46, running from 50 to 80 ft. in length, are readily available. On account of its large average size, therefore, it is probable that the majority of Douglas fir cross ties will generally be manufactured from the heartwood of the timber.

Douglas fir grows under such a variety of climatic and soil conditions, that its exterior physical appearance varies considerably in different localities. As a matter of fact, Douglas fir was named after David Douglas, an English botanist, who explored British Columbia in 1825 to 1830, but, for the foregoing reason, it has been known in the past under a variety of names such as Oregon pine, Oregon fir, Washington fir, yellow fir, red fir, Douglas spruce, red spruce and Puget Sound pine. The use of so many names has been confusing and often misleading, and for these reasons the United States Forest Service has adopted the name of Douglas fir to cover the whole species, grading and density rules being applied in the selection of that kind required for particular uses.

THE PRODUCTION OF CROSS TIES IN 1919.

The following tables give the estimated production of cross ties in the states of California, Oregon and Washington for the calendar year 1919, by distribution of woods and distribution of markets. Much of the information upon which these tables are based is authentic, and the figures can be depended upon as closely approximate, although in some instances it has been impossible to obtain the exact information. This is true particularly in the case of cross ties manufactured from other woods than Douglas fir, redwood and cedar. The cross-tie sizes given, so far as it has been possible to obtain them, may be considered as indicating the market range in dimensions, the greatest range coming in ties manufactured to meet the demands of foreign markets:

ESTIMATED PRODUCTION OF CROSS TIES IN CALIFORNIA, OREGON AND WASHINGTON FOR THE YEAR 1919. (E. & O. E.)

Distribution by Markets.

DOUGLAS FIR.		Number of Pieces.	
For Pacific Coast railroads			
7" x 8", 7" x 9", and 7" x 10" x 8'	.....		5 710 000
For Inland and Eastern railroads — by rail			
7" x 8" x 8'	.....	400 000	
7" x 8" and 7" x 9" x 8' 6"	.....	3 150 000	3 850 000
For Inland and Eastern railroads — by vessel			
7" x 8" x 8' 6"	.....	306 250	
7" x 9" x 8' 6"	.....	918 750	1 225 000
For Export—To United Kingdom			
4½" x 9" x 9'	.....	1 900	
5" x 10" x 8' 6"	.....	212 500	
5" x 10" x 9'	.....	1 362 000	
5" x 12" x 8' 6"	.....	3 000	1 579 400
To West Coast of So. America			
4" x 6" x 4' 6"	.....	15 100	
6" x 8" x 8'	.....	31 100	46 200
To Mexico			
6" x 8" x 6'	.....	2 100	1 627 700
Estimated total for Douglas fir			12 412 700

REDWOOD.	Number of Pieces.	
For Pacific Coast railroads		
6" x 8" x 6'	8 000	
6" x 8" x 8'	78 000	
7" x 8", 7' x 9" and 7" x 10" x 8'	2 489 000	2 575 000
For Export		
To West Coast of So. America, etc.		
6" x 8" x 8'		200 000
Estimated total for redwood		2 775 000
CEDAR.		
For Pacific Coast railroads		
Mostly 7" x 8" x 8'		175 000
YELLOW PINE, WESTERN LARCH, WESTERN SPRUCE, WESTERN HEMLOCK AND OTHER KINDS.		
For Pacific Coast railroads		
7" x 8", 7" x 9" and 7" x 10" x 8'		250 000

ESTIMATED PRODUCTION OF CROSS TIES IN CALIFORNIA,
OREGON AND WASHINGTON FOR THE YEAR 1919.

(E. & O. E.)

Summary by Kinds.

	Pieces.
Douglas fir	12 412 700
Redwood	2 775 000
Cedar	175 000
Other kinds	250 000
Estimated total production, 1919	15 612 700

SUMMARY BY MARKETS.

All Kinds and Sizes.

	Pieces.
For Pacific Coast railroads	8 710 000
For Inland and Eastern railroads by rail. . . .	3 850 000
For Inland and Eastern railroads by vessel. .	1 225 000
For export	1 827 700
Estimated total production, 1919	15 612 700

THE POSSIBILITIES OF THE FUTURE.

Quantity production of Douglas fir cross ties in Oregon and Washington is capable of almost unlimited increase in the future providing the conditions controlling production are favorable. These conditions are based fundamentally upon a purchase price balanced with the requirements of both specifications and inspection rules. It is anticipated that the use of Douglas fir lumber will steadily increase to meet both domestic and foreign demand, and if heartwood cross ties of close-grain wood are called for in future specifications their price again must be rationally balanced with the market for the higher-priced lumber products, inasmuch as these lumber products, bringing the higher prices, can be cut by the mills from the same logs which would be used in the manufacture of the majority of cross ties.

As the quality specified and the consequent cost of cross ties has advanced, it has been a matter of prudent economy to give them some form of preservative treatment in order to get the maximum life out of the higher-priced tie. Thus it is that sapwood ties are rapidly going out of use and heartwood ties are taking their place at the higher price which heartwood commands.

In conclusion, the railroad cross ties produced on the Pacific Coast have been largely a by-product of the lumber mill. In logging operations to-day the smaller growth is left untouched except as removed for piling. With an increased demand for cross ties, however, this smaller growth will doubtless be hewed into ties or cut up in portable or small permanent tie sawmills. Therefore it is quite entirely within the range of possibility that tie production on the Pacific Coast may become in the future a distinct and separate business of itself, as it is east of the Rocky Mountains, correlated with but independent of the lumber mill, and in the wake of the larger lumber logging operations the great forest areas of the Pacific Northwest may offer employment to thousands of laborers in the splitting and hewing of cross ties from the smaller growth and in the lesser logging operations connected with portable or small permanent tie sawmills. What-

ever form the production of cross ties on the Pacific Coast may take in years to come, it is undoubtedly the destiny of Douglas fir to fill the most important part, representing as it does about one quarter of the total stand of timber in the United States to-day. Mechanically perforated promptly after its manufacture to control or prevent checking, to hasten air seasoning and to insure a uniform predetermined penetration of preservative, then economically treated with the maximum conservation of oil possible and with the vitally important reduction of time and temperature made possible by perforating, it is doubtful whether any cross-tie timber will give a better account of itself in the track bed than Douglas fir.

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WOOD PRESERVATION.

BY LOWRY SMITH.*

(Presented February 18, 1920.)

MANY things during the past two years have tended to increase the general interest in wood preservation. The rapidly diminishing supply and greatly increased cost of the more durable woods, together with the high cost of replacement and labor problems, have brought very forcibly to the attention of users of wood the necessity of adopting means of utilizing the less durable woods that possess the requisite mechanical properties, and also of insuring a much greater permanency to whatever kind of wood may be used.

Wood possesses many qualities that make it the most desirable material for many classes of construction, its greatest shortcoming being in the unbalanced relation that exists between its mechanical and physical properties. Wood preservation might be defined as the art of balancing these properties; in other words, the art of imparting to wood the ability to resist decay or destruction by other causes, throughout its mechanical life, in the capacity for which it may be used.

Wood, in common with other organic materials, is subject to deterioration due to many causes, the ones most commonly encountered being decay, attacks of certain animal life and fire. Wood preservation deals with the two first. Fireproofing, while an allied subject, is not of such general interest.

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Research of comparatively recent date has shown decay to be due to the action of low forms of plant life known as "fungi," and not to fermentation of the sap or action of the soil, as was the popular opinion. These fungi subsist on the wood by changing it into food through exuding substances that dissolve certain constituents of the wood fiber. This action changes the color of the wood and so weakens the structure that it becomes soft or crumbly, taking the form known as rotten wood.

Evidence that wood is being attacked by fungi may be seen in the form of growths commonly known as "fungus," "punks," "dog ears," "toad stools," etc., which appear upon a surface. These external growths are the fruiting bodies (corresponding to the bloom or seed pod of a plant) of the fungus, and their functions are to produce spores or seeds which are disseminated by the wind or other mediums. Whenever these spores alight on wood where conditions are favorable, they germinate in the same manner as the seed of a plant, and grow into the interior of the wood, destroying its structure as they progress. In addition to spreading by means of the dissemination of the spores, fungi extend themselves from one piece of wood to another by growing over small intervening spaces. Decay, it is seen, is infectious, and decaying wood is a menace to all wood in its vicinity.

The exterior growths on fruiting bodies are not the destroying agencies of the fungus, and the action of the fungus is not stopped by removing these fruiting bodies as some seem to believe, but where found show that the fungus has reached an advanced stage in the interior of the wood.

To develop, fungi require the same things as other forms of plant life, — that is, food, air, moisture and heat. Warm, damp locations are most favorable to their growth. If they can be deprived of one of these essentials they cannot exist. Since the control of the air, moisture and heat when wood is used out of doors is impracticable, the surest way to stop fungi is to inject into the wood substances that poison their food supply.

The destruction of wood due to various forms of animal life is by no means so great as that due to decay, nevertheless it occupies a very important position in the general subject. The

most commonly encountered destruction of this character is that of piling and other construction timbers, where used in salt water, by marine borers such as teredo and limnoria, and that of various forms of construction timbers by termites or white ants.

Woods available for use in the United States vary greatly in their resistance to decay. The sap portion of all woods will soon decay when exposed to the weather, but the heart portion of some woods is quite durable.

The diminishing supply and high prices of the durable woods in many cases dictate the use of woods not so durable but which possess the necessary mechanical values, and to which resistance to decay can be imparted by preservative treatment. This feature of wood preservation deserves great consideration not only from the viewpoint of economy but also from that of the conservation of our timber supply.

In the past it has been considered that the greatest economy could be effected by confining preservative treatment to the non-durable woods possessing the necessary mechanical properties, due to the fact that they could be purchased at a comparatively low cost. However, due to the deterioration in the quality of the durable woods now obtainable, the timbers from which almost invariably contain quite a large percentage of sap wood, preservative treatment of them as well is now considered good practice.

Some idea of the value of preservative treatment can be had from the knowledge that cross ties which untreated will totally decay in three to seven years, last ten to sixteen years when treated; that piling and timbers which untreated will decay in six to twelve years, last fifteen to thirty years when treated; that piling and timbers which untreated will be destroyed by marine borers in one to four years, last twelve to twenty-five years when treated.

Contrary to the general idea, the art of wood preservation is by no means new, although its greatest progress has been made within recent years. That the ancients practiced it is revealed by Pliny who says they protected wood from attacks by worms by treating it with garlic boiled in vinegar. The

embalming of their dead by the Egyptians is well known to all. The Greeks and Romans recognized the value of certain oils for preserving the wood they used in buildings. The Britons used to preserve the timbers of their warships against decay, either by soaking them in or coating them with linseed oil, tar, etc. The Dutch early learned the value of preserving the timbers used in the construction of their dikes and marine structures. All of the early methods were very crude and did not get enough penetration of the preservative to have any great value other than that of shedding water. It was not until the early part of the nineteenth century that the preservation of wood by the injection of chemicals under pressure became scientific in principle and received any great degree of development.

Many patents covering methods and mediums for preserving wood have been issued both in this country and abroad, and earlier methods have been steadily improved. The mechanical operating features of the processes have also been greatly improved, and the aim of the art to-day is to see that only sound wood in proper condition be treated, and that the necessary protection be afforded with the use of as little preservative as will assure efficiency.

The growth of wood preservation in the United States from 1838, when the first cross ties were treated by the infusion of bichloride of mercury and laid in the track of the Northern Central Railroad, in Maryland, now part of the Pennsylvania System, has been extraordinary. It can best be judged by the fact that in 1900 there were only 15 wood-preserving plants, and that the total number of cross ties treated during that year was only 2 800 000, while in 1919 there were about 100 plants and the number of cross ties treated was over 35 000 000. The increases in the other classes of material treated has been proportional. The first commercial wood preserving plant in the United States was built at Lowell, Mass., in 1848, using alternately bichloride of mercury and chloride of zinc, and it is believed to be in operation at the present time.

The proper preparation of wood for treatment is essential, and it is the recognition of this fact and the improvements made

in connection with it that have been among the most important advances made in the art of wood preservation during recent years. Wood when green contains much moisture which resists penetration of the preservative and must be reduced in volume before successful treatment can be accomplished. This is accomplished by several methods, the most preferable of which is air-seasoning. Kiln-drying or steaming may also be resorted to, as also may be boiling in hot oil. The method depends somewhat on the kind and condition of the wood, but largely on personal preference. With any method and for any kind of wood the first step in its preparation for treatment is the removal of all the bark. When wood is prepared by air-seasoning it is stacked on well-drained ground, free from vegetation, in open piles. The seasoning period varies with many conditions, such as locality, time of the year, kind and condition of wood, and the size of the pieces. It generally varies from four to twelve months. To avoid severe checking, the piles in arid regions should be less open than in humid regions. Certain kinds of wood are apt to split severely while seasoning, but this can be largely overcome by driving into the ends of the timbers irons of proper shape. Wood which is to be air-seasoned should preferably be cut during the winter, as spring and summer are the best seasoning periods.

When air-seasoning is not feasible, steaming is usually resorted to, in which case care must be exercised that the temperature and its duration are not carried to the point of reducing the strength of the wood. After steaming, a vacuum is applied to dry the wood as much as possible.

On the Pacific Coast, in the treatment of Douglas fir, boiling in creosote oil is generally practiced. Recently a process for perforating the surfaces of the wood has been developed, and its use in connection with air-seasoning is expected to take the place of boiling, at least in the case of cross ties and certain structural timbers.

Preservative treatment will not remedy physical or mechanical defects of any kind, consequently only wood which is free from decay, or which has no knots, splits, shakes or other faults of sufficient size or number to weaken it for the purpose

for which it is intended, should be treated. Timber which has to be bored, chopped or otherwise cut into during its erection should be so framed before treatment. The boring of cross ties for the insertion of spikes and the gaining of seats for the plates, before treatment, is being practiced by many railroads at the present time.

The degree of treatment to be given varies with the kind and character of the wood and the purpose for which it is to be used. In all cases the sapwood should be thoroughly penetrated by the preservative, as sapwood is always that portion of wood first affected by decay. Penetration of the heartwood is also very desirable and should be as complete as practicable for the kind of wood used.

Inventors have been busy for years endeavoring to find ways and means for protecting wood against decay and other forms of destruction. Many processes and preservatives have been brought out and demonstrations made to prove their worth, but very few of them have been commercial successes.

A wood preservative's value is determined primarily by its toxicity, permanency, and water-shedding qualities. The toxic values of preservatives vary greatly, and the greater their toxicity and permanence the longer they will prevent decay. Toxic preservatives that will easily penetrate wood, that are permanent, that do not affect its strength, and that are obtainable at a reasonable price, are most efficient and economical.

A large number of substances have been proposed as means of preserving wood, but out of the lot only creosote oil and zinc chloride have come into general use in the pressure processes. Sodium fluoride has shown very promising results, and in some ways would seem to be the most desirable of the water-soluble preservatives. However, its use has not been general or long enough to justify, in the minds of many, ranking it with zinc chloride. Creosote oil is the most important of all wood preservatives, and as recognized by the wood preserving industry is derived from the destructive distillation of coal tar and consists of the fractions distilling off between 200 degrees and 400 degrees Cent.

The amount of creosote oil used in the pressure processes

varies from 5 to 24 lbs. per cubic foot of wood, the maximum quantity being used where it is desired to protect wood from the attacks of marine borers.

Zinc chloride is the principal water-soluble preservative, and is used principally for localities that are not excessively wet or where low first cost is essential. The use of one-half pound of zinc chloride per cubic foot of wood is considered good practice.

The processes of commercial importance that are used in preserving wood are divided into two general classes, the first being non-pressure processes which coat the wood with a superficial absorption, and, second, pressure processes that impregnate the interior of the wood with the preservative injected under pressure. The non-pressure processes are divided into three classes; and first being the simplest and oldest form of wood preservation, which consists of applying the preservative with a brush, using as many coats as considered desirable. Spraying is sometimes used as an alternative. The penetration resulting from these methods is very slight. The second class consists in soaking the wood in hot or cold preservative. This results in a penetration greater than that obtained by brushing or spraying. The third and best class consists of placing the wood in hot preservative for a proper time, after which it is removed and plunged into cold preservative. This results when properly manipulated in by far the best penetration obtained by any of the non-pressure processes, and it is used extensively for the butt treatment of poles and posts. Where only small lots of material are to be treated and the treated wood will not be abraded or split through the coating of preservative, these processes are economical if properly carried out. The best results from non-pressure processes are had only when thoroughly-seasoned wood is used. The results obtained from the use of non-pressure processes are not comparable with those obtained from the use of the pressure processes, and it should be understood that the non-pressure processes are makeshifts and should not be considered in the same class with the pressure processes.

The pressure processes are used wherever large quantities

of material are treated, and obtain deep penetration of the preservative, thereby insuring maximum protection. The depth of the penetration obtainable is dependent upon a number of factors, chief among which are the kind of wood, its moisture content and method of treatment. The almost universal method of impregnating wood with a preservative is by the pressure processes. These processes are carried on in cylinders which range from 72 ins. in diameter and 42 ft. long to 108 ins. in diameter and 172 ft. long, and in which the preservative is forcibly injected into the wood under pressure by means of pumps. The pressure processes are divided into two classes, the first being full-cell treatments, which force into and leave in the wood practically all the preservative it will hold where penetrated, thereby giving maximum protection against decay or attack by animal life for that depth of penetration; the second being empty-cell treatments which aim to reduce materially the final retention of preservative while not reducing the depth of penetration.

The better-known pressure processes used in the United States are:

Bethel (full-cell process).

Lowry (empty-cell process with final vacuum).

Rueping (empty-cell process with internal air pressure and final vacuum).

Burnett (zinc chloride).

Card (zinc chloride and creosote oil).

Complete specifications for these processes as issued by the United States Railroad Administration, Forest Products Section, appear as an appendix to this paper.

In addition to the processes, there are in use on the Pacific Coast for the treatment of Douglas fir the following processes:

Boiling — consisting essentially of the following steps:

Wood (either green or seasoned) in the treating cylinder is immersed in creosote oil.

Oil heated to 225 to 250 degrees Fahr. at atmospheric pressure, and vapors passed through a condenser.

Heating continued until the rate of condensation falls to one sixth to one tenth of a pound of water per cubic foot of wood per hour. This frequently requires forty to sixty hours for green timbers, and sometimes more.

Cylinder filled with cool oil, allowing temperature to fall.

Pressure applied, maximum 120 to 150 lbs. per square inch, until desired injection of preservative is obtained.

Boulton (boiling under vacuum) — consisting essentially of the following steps:

Wood (either green or dry) in the treating cylinder is immersed in creosote oil.

Oil heated to 190 to 210 degrees Fahr., and subjected to a vacuum, the escaping vapors passed through a condenser.

Heating continued until the rate of condensation falls to one sixth to one tenth of a pound of water per cubic foot of wood per hour.

Cylinder filled with cool oil, allowing temperature to fall.

Pressure applied, maximum 120 to 150 lbs. per square inch, until desired injection of preservative is obtained.

The advantage of a Boulton over a Boiling process lies in the fact that the vacuum during the boiling permits the distilling off of the moisture in the wood at much lower temperature which results in less damage to the wood by heat.

There are many other processes, the merits and demerits of which have been or are yet to be demonstrated.

APPENDIX.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF
WOOD WITH CREOSOTE OIL.

(Empty-cell Process with Final Vacuum.)

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be confined in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the American Wood-Preservers' Association:

"Creosote Oil, Grade 1, for Ties and Structural Timber."

"Creosote Oil, Grade 2, for Ties and Structural Timber."

"Creosote-Coal-Tar Solution for Ties and Structural Timber."

"Creosote Oil, Grade 3, for Ties and Structural Timber."

The material shall retain an average of at least 6 pounds of creosote oil per cubic foot for cross ties and 10 pounds per cubic foot of other material, and no charge shall retain less than 90 per cent nor more than 110 per cent of the quantity per cubic foot that may be specified. The quantity of preservative retained shall be calculated, on the basis of 100° F., from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder, the preservative shall be introduced, at not over 200° F., until the cylinder is filled.

The pressure shall be raised and maintained until there is obtained the largest practicable volumetric injection that can be reduced to the required retention by a quick high vacuum. The pressure and temperature within the cylinder shall be so controlled as to give the maximum penetration by the quantity of preservative injected. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches promptly created and maintained until the quantity of preservative injected is reduced to the required retention.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to accurately indicate and record conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Approved:

W. T. TYLER,
Director of Operations.

Approved:

H. B. SPENCER,
Director of Purchases.

WASHINGTON, January 1, 1919.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF
WOOD WITH ZINC CHLORIDE.

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the amount of soluble zinc chloride required.

The material shall retain an average of 0.5 pound of dry zinc chloride per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of this quantity.

The treating solution shall be no stronger than necessary to obtain the required retention of preservative with the largest volumetric absorption that is practicable, and shall be thoroughly mixed before use. Its strength shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, will usually be satisfactory. For example: With red oak the strength shall not exceed

4 per cent, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood it shall not exceed 2 per cent, and the volume injected shall be not less than 40 per cent. The amount of solution retained shall be calculated from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 pounds per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced, the cylinder shall be drained of condensate, and if the vacuum is broken, a second one as high as the first shall be created. The preservative shall be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually raised and maintained at a minimum of 125 pounds per square inch until the required quantity of preservative is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased while the pressure has been held continuously at 165 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 130° F., nor more than 190° F., and shall average at least 150° F. After the cylinder is emptied of preserving solution, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by analysis. Either the "iodine-potassium ferricyanide-starch" or the "potassium-ferrocyanide-uranium-acetate" color reaction test to determine the penetration by its visibility will generally be satisfactory.

From ties samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting treated plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Approved:

W. T. TYLER,
Director of Operations.

WASHINGTON, January 1, 1919.

Approved:

H. B. SPENCER,
Director of Purchases.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF
WOOD WITH CREOSOTE OIL.

(Full-cell Process.)

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the American Wood-Preservers' Association:

"Creosote Oil, Grade 1, for Ties and Structural Timber."

"Creosote Oil, Grade 2, for Ties and Structural Timber."

"Creosote-Coal-Tar Solution for Ties and Structural Timber."

"Creosote Oil, Grade 3, for Ties and Structural Timber."

The material shall retain the amount of creosote oil necessary to permeate all of the sapwood and as much of the heartwood as practicable. The quantities specified may vary from 10 pounds per cubic foot for material from needleleaved trees from which most of the sapwood has been removed to 24 pounds per cubic foot for piling which has wide sapwood. The quantity of creosote oil retained shall be calculated, on the basis of 100° F., from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free of air as practicable. The creosote oil shall then be introduced, without breaking the vacuum, until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 pounds per square inch until the required quantity of preservative is injected into the material or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170° F., nor more than 200° F., and shall average at least 180° F. After pressure is completed and the cylinder emptied of preservative, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material

samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

When permission is given to prepare material for treatment by steaming instead of seasoning by air, it shall not be subjected to pressures or temperatures for periods sufficient to injure the wood.

Approved:

W. T. TYLER,
Director of Operations.

WASHINGTON, January 1, 1919.

Approved:

H. B. SPENCER,
Director of Purchases.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF
WOOD WITH CREOSOTE OIL.

(Empty-cell Process with Initial Air Pressure and Final Vacuum.)

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of an adequate amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of air and preservative with all surfaces.

The preservative used shall be the one most suitable and available of the following standards of the American Wood-Preservers' Association:

"Creosote Oil, Grade 1, for Ties and Structural Timber."

"Creosote Oil, Grade 2, for Ties and Structural Timber."

"Creosote-Coal-Tar Solution for Ties and Structural Timber."

"Creosote Oil, Grade 3, for Ties and Structural Timber."

The material shall retain an average of at least 5 pounds of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor

more than 110 per cent of the quantity per cubic foot that may be specified. The amount of preservative retained shall be calculated, on the basis of 100° F., from readings of working-tank gauges or scales or from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

After the material is placed in the cylinder it shall be subjected to air pressure of sufficient intensity and duration to provide under a vacuum the ejection of preservative necessary to insure the required retention. For example: With red oak pressures of 40 to 60 pounds for 30 minutes, while with pine having a large percentage of sapwood pressures of 70 to 90 pounds for 30 minutes will be required. The preservative shall then be introduced, the air pressure being maintained constant until the cylinder is filled. The pressure shall be gradually raised to at least 150 pounds per square inch, and maintained until all of the sapwood and as much of the heartwood as practicable are saturated, or until the railroad's representative is satisfied that the largest volumetric injection that is practicable has been obtained. The temperature of the preservative during the pressure period shall be not less than 170° F., nor more than 200° F., and shall average at least 180° F. After the pressure is completed the cylinder shall be speedily emptied of preservative and a vacuum of at least 22 inches be promptly created, and maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by sampling ties at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting 'creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

Approved:

W. T. TYLER,

Director of Operations.

Approved:

H. B. SPENCER,

Director of Purchases.

WASHINGTON, January, 1919.

UNITED STATES RAILROAD ADMINISTRATION.
DIRECTOR GENERAL OF RAILROADS.

SPECIFICATION FOR THE PRESERVATIVE TREATMENT OF
WOOD WITH ZINC CHLORIDE AND
CREOSOTE OIL.

Except when ordered otherwise by the railroad's representative, the material to be treated shall be air-seasoned until in his judgment any moisture in it will not prevent injection of the specified amount of preservative; shall be restricted in any charge to woods into which approximately equal quantities of preserving fluid can be injected; and shall consist of pieces approximately equal in size and sapwood content, on which all framing, boring, or adzing shall have been done, so separated as to insure contact of steam and preservative with all surfaces.

The zinc chloride used shall be acid-free and shall not contain more than 0.1 per cent iron. Dry zinc chloride shall contain at least 94 per cent soluble zinc chloride, and in any solution purchased the percentage of zinc chloride specified shall be the quantity of zinc chloride required.

The creosote oil shall meet the standard of the American Wood-Preservers' Association for "Creosote Oil, Grade 3, for Ties and Structural Timber," amended as follows:

- (3) The specific gravity of the oil at 38° C. compared with water at 15.5° C. shall be not less than 1.03 nor more than 1.07.

The material shall retain an average of 0.5 pound of dry zinc chloride and 3 pounds of creosote oil per cubic foot, which shall permeate all of the sapwood and as much of the heartwood as practicable, and no charge shall retain less than 90 per cent nor more than 110 per cent of these quantities per cubic foot.

The preserving mixture shall be composed of the volumetric proportions of creosote oil and of zinc-chloride solution of the necessary strength which are required to obtain the specified retention of the preservatives with the largest volumetric injection that is practicable, and shall be agitated in the working tank and cylinder so as to insure thorough mixing before and while the cylinder is being filled with preservative and while the preservative is being injected into the material. The strength of the zinc-chloride solution shall not exceed 5 per cent and shall be determined by analysis. Chemical titration, using a silver-nitrate solution with potassium-chromate indicator, before the zinc-chloride solution is mixed with the creosote oil will usually be satisfactory.

For example: With red oak the proportions shall be not less than 77 per cent of 5 per cent zinc-chloride solution and not more than 23 per cent of creosote oil, and the volume injected shall be not less than 20 per cent, while with pine having a large percentage of sapwood they shall be not less than

88 per cent of 2.5 per cent zinc-chloride solution and not more than 12 per cent of creosote oil, and the volume injected shall be not less than 40 per cent. The quantities of preservatives retained shall be calculated from readings of working-tank gauges or scales and from weights of at least one-tenth of the material on a suitable track scale before and after treatment, checked as may be desired by the railroad's representative.

Air-seasoned material shall be steamed in the cylinder for not less than one hour nor more than two hours, at a pressure of not more than 20 pounds per square inch, the cylinder being provided with vents to relieve it of stagnant air and insure proper circulation of the steam and being drained to prevent condensate from accumulating in sufficient quantity to reach the material. After steaming is completed, a vacuum of at least 22 inches shall be maintained until the wood is as dry and as free from air as practicable. Before the preservative is introduced the cylinder shall be drained of condensate, and if the vacuum is broken a second one as high as the first shall be created. The preserving mixture shall be introduced without breaking the vacuum until the cylinder is filled. The pressure shall be gradually raised, and maintained at a minimum of 125 pounds per square inch until the required amount of preservatives is injected into the material, or until less than 5 per cent of the total quantity required has been injected during the latter half of one hour throughout which the rate of injection has persistently decreased, while the pressure has been held continuously at 165 or more pounds per square inch. The temperature of the preservative during the pressure period shall be not less than 170° F., nor more than 200° F., and shall average at least 180° F. After the cylinder is emptied of preserving mixture, a vacuum shall be maintained until the material can be removed from the cylinder free of dripping preservative.

At least once each day the railroad's representative shall determine penetration by analysis. With woods on which potassium ferro-cyanide and uranium acetate will produce color reaction, the penetration may be determined by its visibility. From ties, samples shall be taken at middle and rail sections; from other material samples shall be taken as desired. Any holes that may be bored shall be filled with tight-fitting creosoted plugs.

The treating plant shall be equipped with the thermometers and gauges necessary to indicate and record accurately the conditions at all stages during the treatment, and all equipment shall be maintained in condition satisfactory to the railroad. The owner of the treating plant shall also provide and keep in condition for use at all times the apparatus and chemicals necessary for making the analyses and tests required in this specification.

When water-gas-tar solution instead of creosote oil is used, the oil shall be a water-gas-tar product, of which at least 60 per cent shall be a distillate of water-gas tar and the remainder refined or filtered water-gas tar. It shall meet the following requirements:

- (1) It shall not contain more than 3 per cent water.
- (2) It shall not contain more than 2 per cent of matter insoluble in benzol.

- (3) The specific gravity of the oil at 38° compared with water at 15.5° C. shall not be less than 1.03 nor more than 1.07.
- (4) The distillate, based on water-free oil, shall be within the following limits:
 - Up to 210° C., not more than 8 per cent.
 - Up to 235° C., not more than 20 per cent.
 - Up to 355° C., not less than 60 per cent.
- (5) The specific gravity of the fraction between 235° C. and 315° C. shall not be less than 0.98 nor more than 1.02 at 38° /15.5° C.
- (6) The residue above 355° C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70° C.
- (7) The oil shall not yield more than 10 per cent coke residue.
- (8) The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association and the American Wood-Preservers' Association.

When a distillate of water-gas tar instead of creosote oil is used, it shall meet the following requirements:

- (1) It shall not contain more than 3 per cent water.
- (2) It shall not contain more than 0.5 per cent of matter insoluble in benzol.
- (3) The specific gravity of the oil at 38° compared with water at 15.5° C. shall not be less than 1.02.
- (4) The distillate, based on water-free oil, shall be within the following limits:
 - Up to 210° C., not more than 5 per cent.
 - Up to 235° C., not more than 25 per cent.
 - Up to 355° C., not less than 80 per cent.
- (5) The specific gravity of the fraction between 235° C. and 315° C. shall not be less than 0.98 nor more than 1.02 at 38° /15.5° C.
- (6) The residue above 355° C., if it exceeds 5 per cent, shall have a float test of not more than 50 seconds at 70° C.
- (7) The oil shall not yield more than 2 per cent coke residue.
- (8) The foregoing tests shall be made in accordance with the standard methods of the American Railway Engineering Association and the American Wood-Preservers' Association.

Approved:

W. T. TYLER,
Director of Operation.

Approved:

H. B. SPENCER,
Director of Purchases.

WASHINGTON, January 1, 1919.

(Revised January 1, 1920.)

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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DOUGLAS FIR AS A STRUCTURAL TIMBER.

C. J. HOGUE.*

(Presented February 18, 1920.)

DOUGLAS FIR at present constitutes about twenty per cent. of the lumber production of the United States. An increasing knowledge and presentation of its properties, however, is causing a rapidly growing demand for it in markets far distant from the source of supply, and the production will increase annually for many years to come. Many alarmist statements are being made to the effect that our national timber resources will soon be exhausted; a reassuring note, however, may be found in the fact that the Douglas fir forests are at present growing faster than they are being reduced, and their natural reproduction is so prolific that with the growing interest in a national forest policy, adequate fire protection and a logical and economically sound recognition and solution of the burden of interest and taxation involved in re-forestation, there is every reason to believe that the West Coast forests cannot only take up the slack in other producing regions until they can be re-forested and again come into the market, but that the amount of standing timber in Douglas fir need never be less than it is to-day.

New England does not seem in the past to have received Douglas fir of representative quality. This is probably due to

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the fact that there has been no direct connection between the market and the manufacturer and that until recently criterions have not been available for the selection of timbers with particular relation to strength properties. Douglas fir is of medium weight, which means ease in handling; but has remarkable strength properties, and when compared in equivalent qualities is equal in strength properties to any commercial structural timber, and is superior to most.

THE NATURE OF WOOD.

The element of wood structure is the fiber, — a long, slender, hollow cell closed at both ends, communication through the walls of which is by means of microscopic apertures or "pits" in adjacent cell walls. Assembled in wood structure and magnified 50 to 250 times, depending on the species, the arrangement of cells looks very much like the ordinary honeycomb. (See Figs. 1 and 2.)

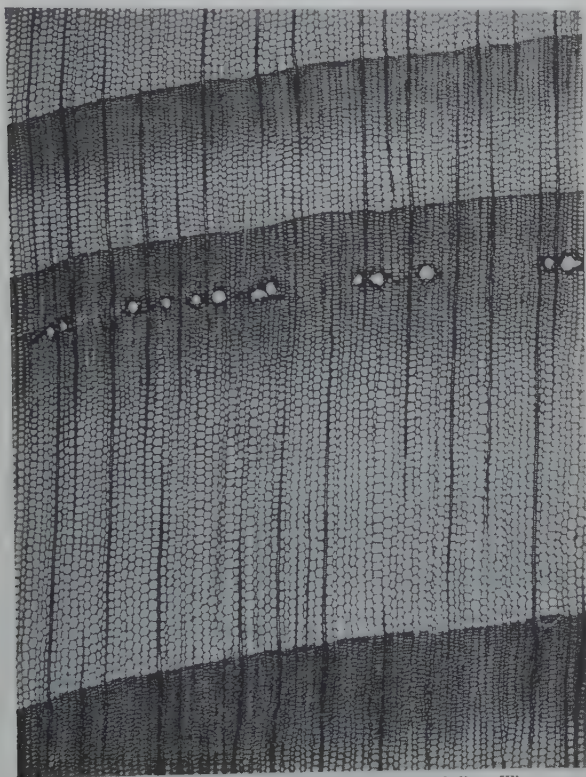
The cellular structure of softwoods is simple, and the cells are largely uniform in size and arrangement; the structure of hardwoods, on the other hand, is complex and is composed of several types of cells and fibers, which vary materially in size, and twist and intertwine to give the toughness and resistance to splitting which are characteristic of that class of wood.

Wood substance, or the material of the cell walls, consists of a skeleton or framework of cellulose, impregnated and filled in with lignin. Both are carbohydrates, of different chemical formulæ but composed of the same elements as sugar and starch. Wood substance is colorless, odorless and tasteless, these properties being added by infiltrated and deposited gums, oils and minerals.

The specific gravity of all wood substance, whether hardwood or soft, light or heavy, varies only slightly from 1.55. The weight, buoyancy and porosity of woods, therefore, are dependent on the amount of wood substance they contain or the relation between the thicknesses of the cell walls and the air spaces or "lumens" within the cells.

The smallest grouping of the cells which can be seen without a microscope, except the pores of hardwoods and, occasionally,

resin ducts in softwoods, is their arrangement in the annual growth rings. In the early or spring growth of most woods the cell walls are thin and the cells are approximately square. In



Courtesy of Forest Products Laboratory, U. S. Forest Service, Madison, Wis.

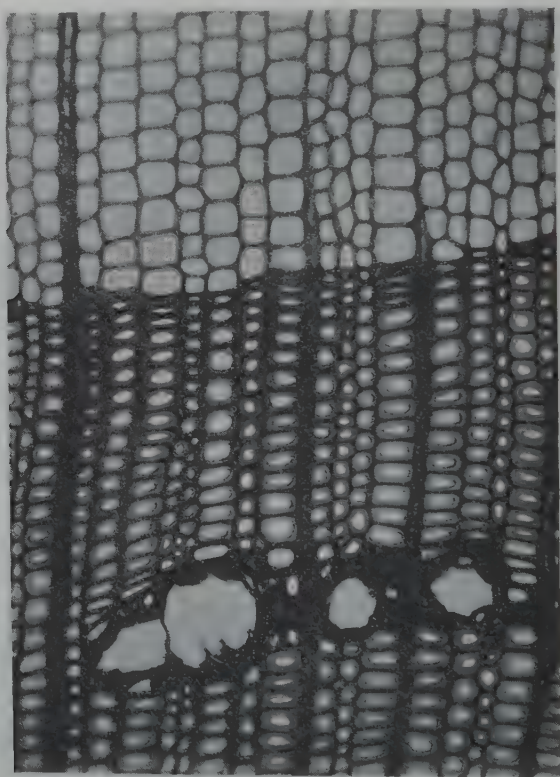
FIG. 1. — CROSS SECTIONS OF DOUGLAS FIR.

Showing cell structure. Thin-walled cells are spring wood; thick-walled cells are summer wood. Large openings are resin ducts.

Section through parts of four annual rings, two of which are complete. From photomicrograph magnifying 50 diameters.

the late or summer growth the cell walls tend to be very much thicker, and the radial dimensions to be less than the circumferential or tangential dimensions; this may be due to tension

in the bark which restrains the growth radially. The reason for the difference in the amount of wood substance in the spring and summer growth is not fully known; one theory is that



Courtesy of Forest Products Laboratory, U. S. Forest Service, Madison, Wis.

FIG. 2. — CROSS SECTIONS OF DOUGLAS FIR.

Showing cell structure. Thin-walled cells are spring wood; thick-walled cells are summer wood. Large openings are resin ducts.

Section through parts of two annual rings. From photomicrograph magnifying 250 diameters.

with the completion of new shoot and leaf growth there is more plant food available for wood production. In some species the transition from spring wood to summer wood is

gradual; in others it is abrupt; but there is usually a decided contrast in color, the summer wood being harder and darker because of the greater amount of wood substance present.

The number of annual rings in the cross section of any tree or branch is a measure of its age, as a tree is completely enveloped each year, trunk, limbs and branches, by the year's growth and, on cutting a tree, the age at which it reached any height can be computed by deducting the number of annual rings at that height from the number at the base.

The second noticeable characteristic in a cross section of a tree or limb is the division of the annual rings into sapwood and heartwood. The sapwood is that next to the bark, and the heartwood that around the center of the tree. The relative proportion of sapwood and heartwood varies in different genera and in different species, and the cause of change from sapwood to heartwood is not known; rings which are sapwood in one part of a tree may be heartwood in another.

The function of sapwood is to serve as a vehicle for the transmission of moisture from the earth to the buds and leaves, where it is transformed into sap or plant food which then descends between the bark and the wood through what is known as the "cambium layer" to give nourishment to the new cells being formed, wood cells on the inside and bark cells on the outside. True sap seldom gets far from the cambium layer.

The heartwood is no longer concerned with the vital processes of the tree, but serves in mechanical support of the weight of the crown.

FACTORS WHICH INFLUENCE STRUCTURAL TIMBERS.

Factors which influence structural timbers are common to all species. A brief discussion of them may be of value, therefore, before considering the limiting factors for Douglas fir.

Locality of growth has some influence on the strength of timber, but its influence is usually overestimated in that there may be as much difference between stands of timber in one region as in widely separated regions. Douglas fir is the one species in which silviculturists recognize two localities of growth — the Pacific Coast region and that of the Rocky Mountains,

the Douglas fir of the Pacific Coast growing under more favorable conditions and therefore developing better qualities.

Atmospheric temperature has little effect on wood, the coefficient of expansion of which is about the same as that of steel and concrete; expansion and contraction, which are factors in the use of wood, are the result of absorption and evaporation of moisture. Moisture content has a decided effect on the strength of wood, strength increasing 50 to 100 per cent. as wood becomes thoroughly dry. This increase in strength is largely offset in large timbers, however, by defects developed in seasoning so that it is unwise to base working stresses on values materially higher than those developed in green timbers. Moisture is contained in wood in the composition of wood substance, by absorption in the cell walls and as free moisture within the cells, and when green there may be a moisture content by weight of as much as or more than the wood substance itself. Drying takes place by the transfusion of moisture to the surface and evaporation there. The free water within the cells passes to the surface first, and there is no reduction in the moisture content of the cell walls until all the free water has been evaporated; when this has taken place and the cell walls are still completely saturated, the "fiber saturation point" is said to have been reached; this is at a moisture content of 20 to 30 per cent. of the weight of the wood substance. Below this point wood is air dried to between 10 and 15 per cent. and kiln dried to 5 or 6 per cent.

Shrinkage does not take place until the moisture falls below the fiber saturation point and the cell walls begin to give up their moisture. Exposed to moisture, wood again absorbs it and expands at about the same rate as that at which it shrank.

Checking in shrinking is due to two causes: a lack of uniformity in the rate of shrinkage throughout the piece and the greater shrinkage of wood circumferentially than radially. The first can be overcome by care in drying; the second is a natural property and allowance must be made for it in pieces of timber size.

Heartwood and sapwood have been determined to be equal in strength properties, but sapwood is less durable when exposed to decay-producing conditions.

Rate of growth is not in itself a definite factor of strength, although softwoods of exceptionally fast or slow growth are usually below the average in strength; hardwoods, on the other hand, are usually of the greatest strength if of rapid, and at the same time dense, growth.

Density as indicated by specific gravity is a close measure of strength. Wood substance is quite uniform in strength, as well as being almost uniform in weight, so that the relative strengths of woods are closely proportional to their weights or the amounts of wood substance they contain.

Specific gravity is somewhat of a laboratory determination, but in many species the proportion of summer wood, the dense, dark portion of the annual ring, furnishes a visual means of determining timbers which are of adequate strength, although sometimes rejecting others equally good.

One of the most dominating factors in the strength of a timber is the size and position of knots. As all normal limb growth starts at the pith and is intergrown with the trunk, knots will always be formed near the center of a tree. As lower limbs die and break off, however, the short projecting portion will first be encased, but not intergrown, and later growth will entirely encircle the remnant of the one-time limb, providing the long lengths of clear lumber available in trees of old growth. The effect of a knot is, of course, largely proportional to its size; it is undesirable to have a rotten knot or one which will drop out; and the location of a knot is a material factor in its effect. The amount and character of stress applied to a knot are large factors in its effect; a knot, while usually harder than the surrounding wood and therefore stronger in compression across the grain, still has in this property only a fraction of the strength of the surrounding wood in compression along the grain. When a knot and the surrounding wood are both in compression across the grain, the knot is not necessarily a source of weakness; when a knot is in a portion of a beam in which the dominant stress is shear, it may be a factor in greater resistance; where it destroys the continuity of surrounding fibers in tension or compression it is a source of weakness.

Shakes and checks are factors of weakness in resistance to shear.

Angle of grain is of two kinds, and both are of importance. Diagonal grain is caused by a log not being cut parallel to the annual growth rings; it can be prevented by care in sawing. Spiral grain is a natural defect due to the fibers in the annual ring departing somewhat from the vertical as if the circle of the annual ring had been twisted slightly about the center of the tree as an axis; this defect is more insidious than diagonal grain because harder to detect, as it may be present in a piece in which the grain as shown by the annual rings is parallel to the edges of the timber on four sides.

Results of tests are not comparable unless many of the above factors are observed and recorded. Tests on small specimens of clear wood must be made on pieces of equal moisture content and specific gravity or the results must be corrected according to known laws for variation in these properties. Additional variable results will obtain in large specimens, depending on the presence or absence of knots, shakes and checks and diagonal and spiral grain.

APPLICATION OF STRUCTURAL FACTORS TO DOUGLAS FIR.

Recognizing the properties and defects which are factors in the strength of timbers it is then a question of setting certain standards which will assure a satisfactory minimum strength and at the same time secure material in sufficient quantity. The principal factors necessary for such selection are: density, rate of growth, size and position of knots, amount of shake and angle of grain.

In applying these factors to Douglas fir it has been found that a specific gravity slightly above .4 will assure adequate strength in clear wood to justify a working stress of 1 600 lbs. per square inch in the extreme fiber in bending, and would be obtained in material having a density visually determined by one third or more summer wood, although some pieces with less than one third summer wood would have adequate strength.

Rate of growth is fixed at not less than six rings per inch unless one half the annual ring is summer wood, and the grain must not be so fine that the percentage of summer wood is not easily discernible.

Knots in beams where a fiber stress of 1 600 lbs. is to be used are limited to $1\frac{1}{2}$ ins. in size in portions subjected to the greatest stresses, while with 1 300 lbs., knots may be 3 ins. if the timber has one third summer wood, otherwise they are limited to $1\frac{1}{2}$ ins. In posts, with a fiber stress of 1 200 lbs., knots are limited to 3 ins., and with 1 000 lbs, to 4 ins. if the wood is of the required density, or 3 ins. if it is not.

Shakes are limited to one fourth the least dimension of the piece, and any combination of shakes and checks to the limit for shakes.

Angle of grain is limited to a slope of 1 in 20 in the center portion of beams, and to 1 in 15 in posts.

Density and structural rules for Douglas fir have recently been adopted by the West Coast Lumbermen's Association, representing over 90 per cent. of the production of Douglas fir. The application of the rules is guaranteed by inspection by the Pacific Lumber Inspection Bureau and by branding.

So many factors enter into the selection of timbers for structural purposes, and their utility is so greatly affected by the relative effect of natural properties and various defects that rigid rules, no matter how carefully prepared, are at best inadequate. The governing principles should be understood, and the rules applied with judgment. They contain minimum requirements and maximum defects, all of which may be present at one time; when the properties and defects of a particular timber vary slightly from the provisions of the rules, however, the relative effect on its strength should be considered in accepting or rejecting it.

DOUGLAS FIR, THE SPECIES.

Douglas fir is a genus in itself (*Pseudotsuga*), distinct from the true firs (*Abies*), and there is only one commercial species (*Pseudotsuga taxifolia*). There are several types, however, which are more or less localized within the regions of growth.

Trees starting their growth in scattered stands are usually of the "red fir" type; they incline to be rather coarse in grain, light in weight and reddish in color. As the growth develops and the tops intertwine and the sunlight is shut out, the rate

of growth becomes increasingly slower and the wood more dense; this is known as the "bastard" stage of growth. After reaching an age of several hundred years the trees become so large and the rate of growth so slow that the wood again becomes low in density; this final stage is known as "old-growth, yellow fir."

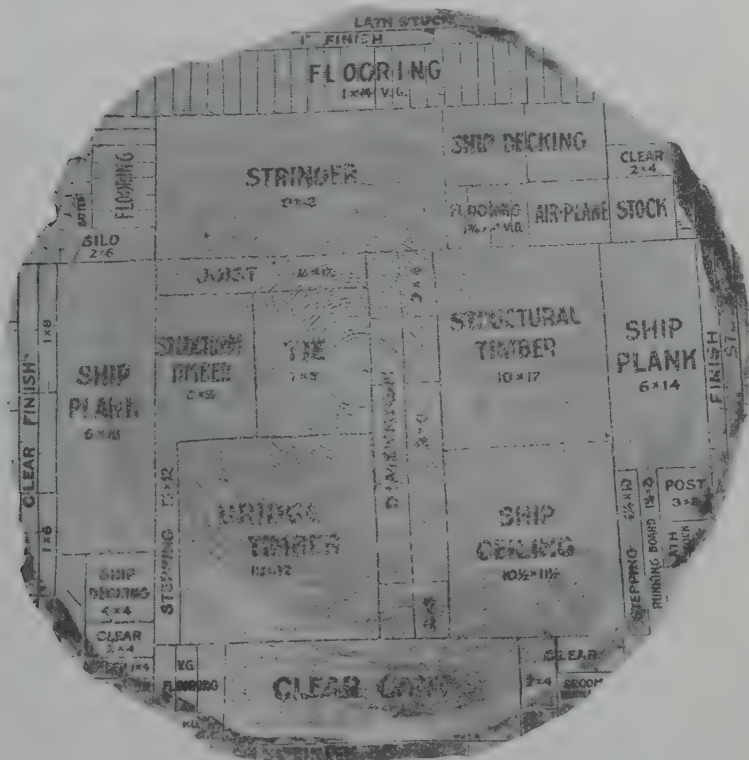
Trees germinating in close stands have a fairly fine grain, yellow color and high density from the start; due to the thickness of their growth, they become very tall and straight, reaching for the light and sun, and this type is known as "young, yellow fir." Some stands of timber are cut while in the red fir stage, and there are types intermediate between young red fir and young yellow fir, sometimes called bastard fir throughout their growth because they are similar to the bastard stage of the large old-growth trees.

The finest finish, siding, etc., comes from the old-growth yellow fir; coarse-grained young growth is cut into the common grades, and structural timbers from young or intermediate growth: young yellow fir; red fir, if not too coarse and light; and bastard fir, either from the bastard type or the bastard stage of the old-growth trees. Spars, masts and flagpoles of young yellow fir are in demand the world over, and are frequently known as of "Oregon pine." Fig. 3 shows the location of various grades and kinds of timber in a typical log.

Douglas fir has been at a handicap in comparison with pine, in that, in that genus, species names have largely come to have quality, rather than botanical, meaning. There are some 35 recognized species of pine, of which 15 are of commercial importance. Of the half dozen odd species of southern pine, those of principal structural importance, although each has the range in character and strength which is typical of any species, the commercial market has largely come to accept timbers of close grain and high density as "longleaf," whether actually of that species or not, pieces of close grain and light weight as "shortleaf," and pieces of coarse grain and light weight as "loblolly."

It was in recognition of the fact that the species did not matter if density were present, that the "density" grading rule

for southern pine was first proposed. The market, however, having previously begun to identify quality under species names, largely accepted the density grading rule as defining what it had begun to know as "commercial longleaf," and continued to a great extent to use this term.



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FIG. 3.—THE DOUGLAS FIR "INDEX" LOG.

Showing location of various grades and kinds of timber in a typical log, and narrow ring of sapwood.

There being no such available species names to be applied to Douglas fir, it became necessary to adopt a density grading rule which would identify the growth of Douglas fir which gives

comparable values with "commercial longleaf" or "dense" southern pine.

Douglas fir is a remarkably strong wood for its weight; its strength, in terms of specific gravity, being materially greater than the average of American woods. This makes it a material of much greater strength than woods of its own weight and equal in strength to much heavier woods.

The West Coast believes it is offering to the Eastern market a material, not in competition with something else equally good and equally abundant in supply but one the equal of any it has ever had and the superior of many, and at a time when material comparable in quality is becoming increasingly difficult to obtain.

With the lightness of the spruce and the strength of the pine, with a mutual understanding on the part of the manufacturer of the needs of the market, and on the part of the purchaser of the properties and characteristics of the material available, and with a guide for selection which will identify and secure the character of material desirable, it is believed that the New England market will find great satisfaction in the introduction of West Coast woods.

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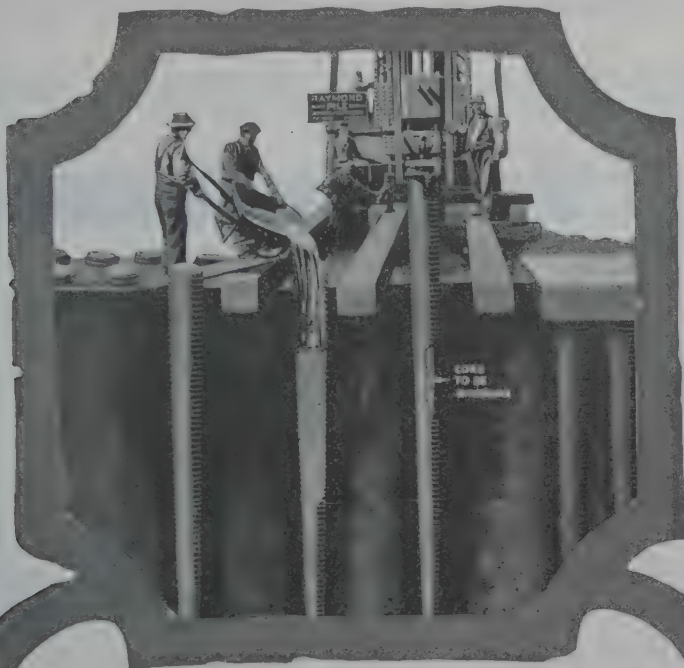
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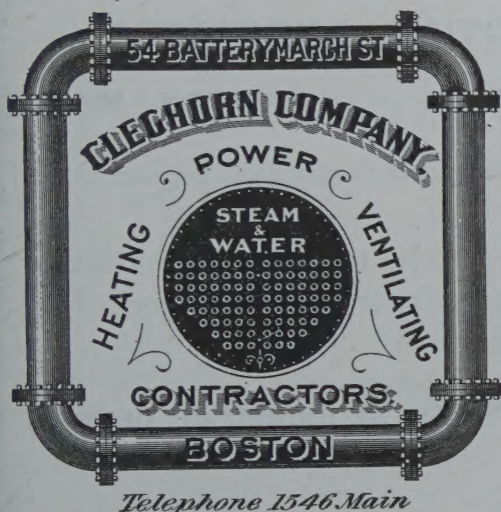
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